Plant 39

SLIDING TOWARD EXTINCTION: THE STATE OF CALIFORNIA'S NATURAL HERITAGE, 1987

Prepared at the Request
of
The California Senate Committee
on
Natural Resources and Wildlife

Commissioned by:
The California Nature Conservancy
San Francisco, CA

Prepared by:
Jones & Stokes Associates
Sacramento, CA

November 1987

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INTRODUCTION

The Natural Diversity Issue

California has one of the most diverse assemblages of plants, animals, and natural communities in the United States. As Aldo Leopold (1953) noted, the first precaution of intelligent tinkering is to save all the pieces. Yet, in California we have been rapidly eliminating and modifying natural habitats without fully understanding which pieces of our natural biological heritage may be lost and the consequences of these losses. Approximately 220 vertebrate animals, 600 species of plants, and almost 200 different natural communities in California are considered by many to be threatened with severe reduction or even extinction. Decisive action is needed to protect significant amounts of a variety of habitats to prevent the loss of species now sliding toward extinction.

The decline in natural biological diversity has only recently become a prominent public issue. Daily, the news media bring new aspects of the problem to our attention. The popular and scientific literature dealing with endangered species, habitat protection and management, and the emerging field of conservation biology is growing rapidly. Nationwide membership in conservation organizations is higher than ever. Many major conferences addressing natural diversity issues have been held recently throughout North America, including California. Loss of natural diversity is becoming a major political, social, and scientific issues of our time.

Purposes of this Report

The protection of natural diversity is important in California for several reasons. First, California's Mediterranean climate, geographic position, and diverse topography, geology, and soils all have combined to produce a tremendous variety of habitats and plant and animal species; many of these species and habitats are unique to the state. Second, California's rich resource base and mild climate have attracted a large and growing human population, which has caused, and continues to cause, a loss of many habitats and species. Third, unless adequate protection measures are applied in advance, conflicts between development and protection of endangered species and habitats will continue to escalate; such conflicts are harmful both to our biological heritage and the state's economy.

The purposes of this report are to assess the status of natural diversity in California, and to inform legislators, public agencies, private organizations, and individuals of actions that can be taken to improve the protection of natural diversity in California.

We examine the condition of natural diversity in California by answering the following questions to the extent that current scientific knowledge allows:

1. What is the extent and character of natural diversity in California, and how does this compare with other parts of the United States?

2. How many species have become extinct in California, and how many others are threatened with future extinction?

3. What are some of the most serious examples of habitat loss in California?

4. What factors pose the most serious threats to natural diversity in California?

5. How effective is California's legal system and its system of parks, preserves, and other natural areas in protecting important components of California's biological heritage?

6. What new actions are needed to ensure protection of California's biological heritage?

These questions are addressed in the following chapters. Chapter 2 defines natural diversity and describes the values it provides. Chapter 3 reviews inventories of biological resources in the state and analyzes historical trends in wildlife and plant populations, habitats, and human activities. Chapter 4 analyzes the protection given to California's natural diversity through laws and regulations, land ownership, and land management. Chapter 5 examines case studies of selected biological communities. Chapter 6 concludes with a list of recommended actions to help ensure the perpetuation of our outstanding natural heritage.

Chapter 2

NATURAL DIVERSITY: WHAT IT IS AND WHY WE NEED IT

What is Natural Diversity?

Picture a large California river bordered with deep forests of towering valley oaks, cottonwoods, box-elders, and willows. Envision its canopy draped with wild grapes, shading dense thickets of wild blackberries, elderberries, and button-willows. Imagine, on a warm, humid, summer morning, the sounds of hundreds of birds, including yellow-billed cuckoos, yellow warblers, willow flycatchers, lazuli buntings, and many others singing in the canopy, and the buzzing of thousands of cicadas, midges, and other insects. This is an example of a naturally diverse community.

To the scientist,"natural diversity" has a variety of meanings. These include: 1) the number of different native species and individuals in a habitat or geographical area, 2) the variety of different habitats within an area, 3) the variety of interactions that occur between different species in a habitat, and 4) the range of genetic variation among individuals within a species.

Natural diversity, as used in this report, is synonomous with biological diversity. Ecologists have described several types of biological diversity that have subtle differences. Recognizing these differences is important because all aspects of diversity must be considered in developing effective management for protected species and habitats.

Natural diversity is most often used to describe an area's species richness; this measure is the number of species living in a given geographic area. Species richness at a given area is determined by the number of species within individual habitats and the variety of habitats present in an area. Greater habitat diversity creates greater species richness because different types of habitats tend to support different species (Whittaker 1970, Norton 1986). California, for example, has much greater habitat diversity and total species richness than New England, even though the two areas are similar in size.

At the species level, "genetic diversity" refers to the amount of genetic variability among individuals of a species or local population (Frankel and Soule 1981). Ponderosa pines, for example, have many different forms of genes spread among individuals. These genetic differences produce variations in appearance, ecological adaptability, and cell chemistry. The species occupies a wide geographic range and a variety of environmental conditions. Torrey pines, on the other hand, lack genetic diversity; their genes are virtually identical from one individual to another. The species is restricted to a few small populations. Regardless of the terminology used, natural diversity means richness in biological species and habitats, and complexity in biological processes.

Losses of Natural Diversity

Loss of diversity can be dramatic, as in the extinction of a majestic species such as the California grizzly bear, or the destruction of a rich natural community such as an old-growth forest. It also can be subtle, as in the gradual loss of populations of the riparian brush rabbit, the displacement of native coastal shrubs by the invasion of nonnative plants, or the depletion of genetic variation in the Modoc sucker.

Losses of species diversity can be described in several ways. "Extinction" is the complete loss on a global scale of all living members of a species (or subspecies or other taxonomic entity). Extinction is irreversible because there is no way to reconstitute a species once all of its individuals have vanished.

"Extirpation" is the loss of a species' population from a particular location or region. Local extirpations occur normally during successional changes in many natural communities, or abnormally due to human disturbance and loss of habitats. Extirpation of bald eagle populations from many areas of the United States, for example, indicated detrimental effects of pesticides and human disturbance (Krantz et al. 1970, Sprunt et al. 1973, Grier 1982). A series of extirpations on a regional or global scale can ultimately lead to extinction.

Far more subtle than extinction or extirpation is the loss of genetic diversity as species populations become too small, too scattered for effective mating, or too closely inbred. This "genetic depletion" can threaten a species with extinction by reducing its ability to cope with short-term or long-term environmental changes. For example, climatic change over time can lead to extinction of a genetically depleted species that is unable to adapt to a modified habitat (Gilpin and Soule 1986, Ledig 1986).

Changes in natural diversity have, of course, occurred naturally at various times since the origin of life. Some losses have been catastrophic, such as those caused by volcanism or other large-scale geologic events; most losses, however, have occurred gradually, such as those resulting from global climatic changes. Following extreme periods, new species have evolved during other more favorable conditions to replace lost ones.

Since man became a dominant influence on global ecology, the situation has changed dramatically. Species extinctions and habitat losses are occurring now at rates far greater than at any time in the past. By the 17th century, species were disappearing at an approximate rate of one per 4 years. Today, the world is losing at least one bird or mammal species each year (Myers 1979).

Although little is known of the rates of extinction among groups other than birds and mammals, evidence is overwhelming that rates of extinction today are far greater than at any time in the last 70 million years. Worldwide, we may be losing several species from all plant and animal groups every day due mainly to habitat losses. Most losses of species have resulted from habitat destruction from human activity especially in tropical forests. If the extinction rate continues to rise as it has in recent decades, perhaps as much as one-fifth of all species on earth will have vanished by 2000 (Myers 1979).

Values of Diversity

Biological diversity currently contributes many direct and indirect benefits to mankind. These benefits may be classified as material resources, ecological services, scientific values, and intrinsic values. Many potential future benefits may have been lost and continue to be eliminated before they are even fully understood. Many such losses are irreversible, leading the noted biologist E. O. Wilson (1980) to conclude that the wholesale loss of global natural diversity "is the folly our descendants are least likely to forgive us."

Material Resources

The most tangible value of natural diversity is the material resources provided by certain species. Thousands of plant and animal species provide man with food and drink, fuel and energy, fabrics and ornamentation, medicines, building materials, and industrial products (Myers 1983, Fitter 1986).

Nearly all wine grapes grown commercially in the world are grafted to insect-resistant rootstock derived from the native California grape. This wild species saved the European industry when all vines were destroyed between 1870 and 1900 (Wachtel 1984). Seeds from the endangered Bakers meadowfoam and other species in the same genus, natives of California's vernal pools, produce an oil with unique properties that may be useful as an industrial lubricant and a pharmaceutical (Jain et al. 1977).

Medicines derived from naturally evolved plant compounds provide the most striking examples of the human dependence on biological diversity. Thousands of plants around the world have important medicinal uses. Half of all pharmaceuticals sold in the United States each year, worth 40 billion dollars, are

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derived from biological organisms, largely plants. Relatives of California's endangered Antioch Dunes evening primrose, for example, produce oils that may be useful in treating heart disease, excema, and arthritis (Raven 1982). Of 76 major pharmaceutical compounds used in this country, only seven can be produced economically through artificial synthesis (Myers 1983). Thus, many Californians literally owe their lives to natural diversity, through medicines derived from plants and animals.

Many plant species that are directly useful to man (i.e., for food, medicine, and fiber) have evolved useful qualities in response to certain ecological pressures or environmental conditions. Faced with these problems, many plants have evolved to produce toxic chemicals or nutritious fruits, have grown specialized morphological features, or have adapted to thrive under severe environmental stresses. Many of these survival strategies, however, increase a species' vulnerability to extinction from human disturbance. Ironically, therefore, many of the species which are most likely to be of direct value to people are are also among those most susceptible to extinction (Norton 1986).

The rapidly developing field of genetic engineering promises major opportunities to take advantage of useful characteristics of native plants. Through genetic recombination, genes from one plant may be transferred to another to produce useful qualities. For example, resistance to insects or disease, or tolerance of heat or saline soils, could be transferred from native plants to crops, thereby greatly increasing production. This new view of species as repositories of transferable genes greatly increases the future value of protection of species and genetic diversity (Eisner and Schurman 1983).

Humans are highly dependent on many other species for comfort and survival. Each new extinction of a species can be compared to the removal of a rivet from a spacecraft on which the human species rides (Ehrlich and Ehrlich 1981). Each loss increases the risk of a catastrophic breakup of the system. Unfortunately, it is impossible to predict which new extinction might trigger such a catastrophe. Each species in an ecosystem, like each rivet in a spacecraft, strengthens the entire structure which protects the passengers of "spaceship earth."

Ecological Services

Equally valuable to humans, but more difficult to quantify, are the "ecological services" provided by diverse natural communities and ecosystems. These services include benefits resulting from protection of watersheds and floodplains, moderation of climate, abatement of water and air pollution, biological control of pest populations, and maintenance of habitat for wild crop pollinators and for species providing food or recreation for humans (Bertrand 1984, International Union for Conservation of Nature and Natural Resources 1980). As human populations and resource consumption grow, they threaten the ability of natural ecosystems to continue providing these services at the same time that, ironically, we are becoming more dependent on them.

Maintaining ecological services through protection of natural ecosystems is very inexpensive compared to the technological alternatives. Technologies to control floods, abate pollution, and control pests often expensive, hazardous, ineffective, and often have far-reaching adverse side effects. There are no technological alternatives to biological systems for certain natural functions such as moderating climate or providing disease resistance for our crops.

Scientific Values

Biological diversity is essential to the advancement of science and technology. Every species and ecosystem can provide us with practical knowledge for managing the environment and improving our economy and quality of life. Losses of species and of genetic diversity within species eliminate many opportunities for research, discovery, and the betterment of human life. The undisturbed ecosystems protected in our national parks, wilderness areas, and other reserves provide invaluable natural laboratories for research in watershed management, game management, range management, and the effects of air pollution. Natural ecosystems are vital to the research needed to validate models of global oxygen balance and other large-scale biogeochemical processes.

Plant and animal species are basic tools for research in medicine, genetics, and evolution. They also serve as tools for essential investigative methods in archaeology, climatology, geology, oceanography, and other disciplines. Preserving the genetic diversity in wild relatives of major food crops is absolutely essential in research efforts to increase modern agricultural crop yields through development of more efficient crop varieties and disease- and pest-resistant strains (Office of Technology Assessment 1987, Meyers 1983).

Intrinsic Values

In addition to the many practical values, natural diversity also has intrinsic values. Many people believe that all species have the right to continued existence and, thus, humans have no right to cause the extinction of another life form (except for organisms that cause diseases in humans, domestic animals, and crops). We also have an obligation to provide conscientious stewardship of natural resources for the benefit of our neighbors and of future generations (Callicott 1986, Doming 1986, Gunn 1980, Naess 1986).

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Chapter 3

CALIFORNIA'S NATURAL DIVERSITY: A STATUS ASSESSMENT

The Extent of Natural Diversity in California

Native and Endemic Species

The simplest way to measure the natural diversity of an area is to count the number of different native organisms. Another important consideration in evaluating an area's value for biological diversity is the number or percentage of organisms that are endemic (i.e., found nowhere else in the world). The numbers of native and endemic animal and plant species are very high in California.

Vertebrates. California harbors about 748 species of native vertebrate animals and a high number of endemics (Table 1). About 38 percent of freshwater fish, 29 percent of amphibians, and 9 percent of mammals occurring in California are found nowhere else.

California's diverse topography, varied climate, and complex mosaic of natural habitats promote a uniquely rich bird life. More than 550 bird species (including irregularly occurring "vagrants") have been recorded in California (Laudenslayer and Grenfell 1983). Of these, 349, or 57 percent of all North American birds, occur regularly in California. Some 276 breed regularly within the state (Small 1974). Most of California's bird species have been recorded elsewhere, but the yellow-billed magpie has never been observed outside the state, and the California condor (now living only in captivity) has occurred only in California in recent times. Four bird species, the ashy storm-petrel, elegant tern, Xantu's murrelet, and California thrasher, breed within the United States only in California (Small 1974). Many subspecies of more widely distributed bird species are endemic to California (Grinnell and Miller 1944).

Vascular Plants. Almost 5,200 species of native vascular plants are found within the boundaries of California. Many of these are represented by two or more subspecies or varieties, so the number of recognizably different native plants is actually over 6,800 (Howell 1972, Shevock and Taylor in press). By comparison, this is 14 percent more plant species, and roughly the same number of subspecies and varieties, than occurs in all of the central and northeastern United States and adjacent

Table 1. Numbers of Native and Endemic Species in California

	Mammals	Birds	Reptiles	Amphibians	Freshwater Fishes	Vascular Plants
Native Species[a]	214	349	74	45	66	5,143
Endemic Species[b]	19	3	4	13	25	1,590
Percent of Native Species	9%	1%	5%	29%	38%	31%

NOTES:

[a] Occurring naturally within the state. Species represented by more than one native subspecies or variety are counted only once. Not counted are 16 introduced mammals, 8 introduced and 185 irregularly occurring birds, 3 introduced reptiles, 2 introduced amphibians, 44 introduced freshwater fishes, and about 1,000 introduced vascular plant species. Sources for animals: Laudenslayer and Grenfell (1983), McGinnis (1984); sources for plants: Howell (1972), Shevock and Taylor (in press).

[b] Occurring only within California--nowhere else in the world. Does not include more widespread species with endemic subspecies or varieties. Source for animals: (Csuti pers. comm.); sources for plants; Noldeke and Howell (1960), Howell (1972), Shevock and Taylor (in press).

Canada, an area more than six times the size of California (Fernald 1950).

About 31 percent of the species and up to 62 percent of the subspecies and varieties of plants in California do not occur outside of the state. In the California floristic province (i.e., central and coastal California west of the Sierra-Cascade crest and the deserts), an extraordinary 48 percent of native plants are endemic (Raven and Axelrod 1978).

Plants restricted to California include such well-known symbols of the state's biological heritage as the giant sequoia and Monterey cypress. Several other trees that Californians often think of as common and widespread are, in fact, found nowhere else in the world. These include the blue oak, valley oak, digger pine, and California buckeye.

Other Species. The numbers of invertebrate animals, non-vascular plants, and microorganisms native to California have been estimated for only a few taxonomic groups. For example, California is home to about 25,000 species of native insects, more than 30 percent of all insect species known to inhabit America north of Mexico (Powell and Hogue 1979, Hogue pers. comm., Arnett 1985). California's nonvascular flora includes 1,000-1,200 lichens (Tucker and Jordan 1978, Thiers pers. comm.), 4,000-5,000 gilled fungi (Thiers pers. comm.), 300-400 slime molds (Kowalski 1987, pers. comm.), and 660 mosses and liverworts (Norris pers. comm.). Little is known about the levels of endemism among these groups in California because they have not been completely inventoried. Endemism rates in many of these groups, however, are probably comparable to those in more familiar groups of plants and animals.

Natural Communities

In addition to plant and animal species, California possesses a remarkable number and variety of natural communities. These communities are assemblages of plants and animals that have a recognizable composition and structure, and recur predictably in certain habitats over certain geographic areas. Familiar examples include redwood forest, Joshua tree woodland, coastal sage scrub, chamise chaparral, wet montane meadows, coastal saltmarsh, mountain streams, and kelp beds.

The California Department of Fish and Game's (DFG) California Natural Diversity Data Base (NDDB) has developed a classification system that recognizes 380 different types of natural communities in California (Holland 1986, Ellison 1984). Included among the 260 terrestrial and 140 aquatic communities are at least 80 different types of forest, 34 kinds of chaparral, and 22 types of lakes. Many of these natural communities, such as northern claypan vernal pools, northern basalt vernal pools, Ione chaparral, valley oak riparian forests, and central coastal sage scrub, are endemic to California.

Why California Has So Much Natural Diversity

Causes of Biological Diversity

California supports an exceptional degree of biological diversity because it has many different climates and a varied geology, topography, and climatic history. Eleven different physiographic provinces are recognized in California (Figure 1). Each of these is characterized by a different combination of landforms, habitats, and associated biological communities. Each species or community of species lives within definite limits of variability in topography, soil, and climate.

Climate. California possesses about 20 different regional climate zones (Kimball and Brooks 1959, Stebbins 1976). Most other states have only a few. Average annual rainfall varies from less than 5 inches in Death Valley to over 120 inches in Del Norte County. Seasonal variation in climate may be slight, as in the coastal zone from Santa Barbara to San Diego Counties, or extreme, as in the high inland deserts from Inyo to Modoc Counties.

Most of California's climate is Mediterranean with hot, dry summers, and cool, wet winters. California is the only place in North America and one of only five areas of the world with such a climate. Non-Mediterranean climates prevail in the deserts and in the northwestern corner of the state. Climatic variation is thought to account for more of the floristic differences within the state than any other single factor (Richerson and Lum 1980).

Geology and Soils. The geology and soils of California are also remarkably diverse. Rocks comprising the California landscape range in age from about 1.8 billion years to less than 100 years (Norris and Webb 1976), these parent materials vary greatly in chemical and physical properties. Of the 10 major soil orders recognized worldwide, all are represented in California. About 1,800 different soil series are recognized in California by the U. S. Soil Conservation Service (Hoppis pers. comm.).

Many of California's plants are restricted to soils derived from particular kinds of rocks such as granite, limestone, serpentinite, or volcanic ash. Plant species in danger of extinction that are restricted to unique kinds of soils include the Tiburon mariposa-lily, Mono Craters milk-vetch, and Contra Costa wallflower. Several of the state's animals (e.g., San Joaquin kit fox, several rare forms of kangaroo rat, and the California legless lizard) have specialized burrowing habitats or cover requirements and are restricted to specific soil types.

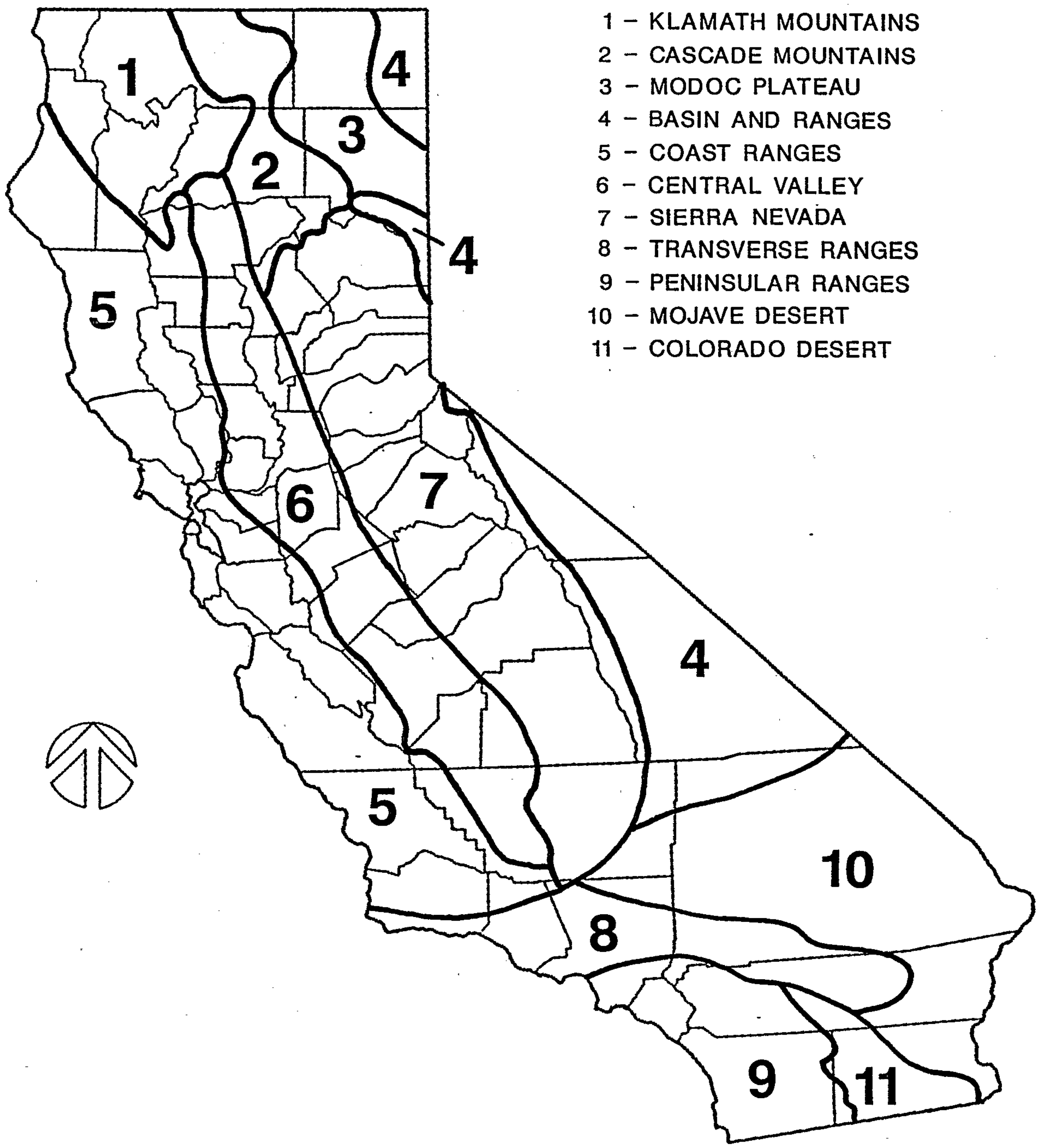

FIGURE 1. PHYSIOGRAPHIC PROVINCES OF CALIFORNIA

Source: Durrenberger and Johnson 1976

Topography affects organisms directly through steepness of slope. It affects them indirectly, through its influence on other variables such as microclimate, exposure to weather, soil depth, soil temperature, and the character of vegetation cover.

Climatic History. Long-term climatic shifts have enriched California's biota by creating habitats for species that originated in other parts of North America. During warmer and drier prehistoric periods, species from the deserts and mountains of Arizona and Mexico moved farther north. In cooler and wetter periods, species from the arctic and boreal zones of Asia and Canada moved southward through the Cascade Ranges and Sierra Nevada. Many of these southern and northern species took up permanent residence in suitable habitats. Some newly established residents differentiated genetically from their ancestors in adapting to new habitats and thus became native members of California's flora or fauna.

Endemism: A Special Type of Diversity

Many plant and animal species in California are endemic. Endemic species develop when a formerly widespread species is reduced to a small remnant population due to climatic change, or a population of a species becomes isolated and evolves into a new species while adapting to new local environmental conditions (Stebbins and Major 1965).

Some endemics are biological artifacts of ancient California. They were more abundant and widespread when the climate was either more subtropical, warmer, and drier, than today (before the ice ages) or cooler and wetter than today (during the ice ages). As climates changed, these species took refuge in remaining areas that either resembled their original habitat or protected them from competition with other species that would make their survival impossible. Botanical examples include the Catalina ironwood, restricted to the Channel Islands; the Torrey pine, at La Jolla and on Santa Rosa Island; the giant sequoia, confined to mid-elevation benches of the western Sierra Nevada; and dedeckera, a shrub restricted to carbonate rocks in remote desert canyons of Inyo County (Stebbins and Major 1965).

Many of California's endemic animal species were also more widespread in prehistoric times. Fossil remains reveal that California condors once occurred through much of the western U. S. (Koford 1953). In more recent times they have been recorded only from California and Oregon (Grinnell and Miller 1944).

The limestone salamander is currently found only in isolated limestone outcrops in the central Sierra Nevada (Stebbins 1985). Similarly, the Mt. Lyell salamander is confined to exposed granite in the Sierra Nevada from Sonora Pass south to

Sequoia National Park. Both species may be surviving remnants of a formerly widespread species that survived the ice ages only in isolated refuges of suitable habitat. Both salamanders have probably failed to expand their ranges due to low mobility and a lack of suitable habitat along potential dispersal corridors.

At the end of the Pleistocene Ice Ages, the Owens, Amargosa, and Mojave River systems drained into a lake on the now dry floor of Death Valley. These river systems have become isolated and each supports its own endemic fish species. The Amargosa River system supports seven endemic species of pupfish and killifish, including 10 recognized subspecies (Moyle 1976). The high degree of endemism in these rivers results from their long period of isolation from other habitats by the harsh desert environment. For example, pupfish have evolved into separate species following their confinement to small, isolated springs (Moyle 1976).

Other endemic species have more recently evolved as a result of isolation and adaptation to changing and local conditions. Recently evolved members of the California flora include several species of live-for-ever, phacelia, and bed-straw, many of which have very restricted distributions (Stebbins and Major 1965). Recently evolved animals include the many subspecies of ensatina salamanders (Stebbins 1964) and San Joaquin kangaroo rats (Williams 1985).

Endemic species are frequently clustered in areas known as "centers of endemism." Centers of endemism are typically associated with distinct habitats or environments, such as mountainous topography, unique geology or soil types, and unusual climatic conditions. Examples of centers of endemism are the Santa Barbara and Santa Cruz Islands, the Monterey Peninsula, Mt. Diablo, the Ione and Pine Hill geologic formations of the Sierra Nevada foothills, the White and Panamint Mountains of Inyo County, and Gasquet Mountain in Del Norte County (Stebbins and Major 1965, Raven and Axelrod 1978).

The Status of Natural Diversity in California

Extinctions

The complete elimination of a species or subspecies from California represents the most extreme type of natural diversity loss. The number of extinctions that have occurred in California since the first Spanish settlement in 1769 cannot be known exactly. Some doubtless occurred even before the species were known to science.

At least 7 species or subspecies of California vertebrates and 16 invertebrates are known to have become extinct in the last 150 years (California Department of Fish and Game 1983a, Singleton pers. comm.) (Table 2). Eight species of vertebrates and two species of invertebrates have been completely extirpated within the state, although they still occur elsewhere. In addition, four other bird species have been extirpated as breeding species in the state, but occur during nonbreeding seasons. Extinctions and extirpations have occurred from many causes, including habitat loss and degradation, direct persecution, and introduction of nonnative species.

The number of plants pushed to extinction in California is difficult to determine accurately. Some plants once presumed extinct have recently been rediscovered; others described long ago may not be valid species. To the best of our knowledge, at least 25 and perhaps more than 30 kinds of California plants are certain to have become extinct in the last 150 years (Smith and York 1984, York pers. comm.).

Threatened and Endangered Species

Numbers of Species. California contains many plants and animals that are officially recognized as threatened or endangered. The California and federal Endangered Species Acts define an "endangered species" as "any species [other than an insect pest] which is in danger of extinction throughout all or a significant portion of its range," and a "threatened species" as "any species which is likely to become an endangered species in the foreseeable future throughout all or a significant portion of its range."

In addition to these "listed" species, many other species may qualify for such listing, but have not yet been legally designated. These species include "Candidates" under review for possible listing under the federal Endangered Species Act, and the State of California's "Species of Special Concern" (Remsen 1978, Williams 1986). Other species are believed to be greatly reduced, but available information is insufficient to support Candidate or Special Concern status.

Table 2 lists the number of species in each of these categories for several major groups of animals and plants. The term "species" is used here to refer to both full species and species in which one or more subspecies or variety is threatened or endangered.

Species that are officially listed as either threatened or endangered comprise a large fraction of the California fauna and flora. About 10 percent of native mammals, 17 percent of native reptiles and amphibians, and 27 percent of freshwater fish are listed by the state or federal governments as threatened or endangered. Altogether, 80 species, or 11 percent of all vertebrate animals, are listed. About 2 percent of California's vascular plants are listed as threatened or endangered.

Table 2. Native California Animal Species and Subspecies Extinct or Extirpated from the State

Fish

Shoshone pupfish (SSP, E)[a]
Tecopa pupfish (SSP, E)
Clear Lake splittail (SP, E)
Thick-tailed chub (SP, E)
Bull trout (SP, E-CA)

Birds

Common loon (SP, E-CA/B)
Barrow's goldeneye (SP, E-CA/B)
Harlequin duck (SP, E-CA/B)
California condor[b] (SP, E)
Harris' hawk (SP, E-CA/B)
Sharp-tailed grouse (SP, E-CA)
Yellow rail (SP, E-CA)
San Clemente Bewick's Wren (SSP, E)
Santa Barbara song sparrow (SSP, E)

Mammals

Gray wolf (SP, E-CA)
Long-eared kit fox (SSP, E)
Grizzly bear (SP, E-CA)
Mexican jaguar (SP, E-CA)
White-tailed deer (SP, E-CA)
Bison (SP, E-CA)

Invertebrates[c]

Pasadena freshwater shrimp (SP, E-CA)
Sooty crayfish (SP, E-CA)
Antioch Dunes katydid (SP, E)
Yorba Linda trigonoscuta weevil (SP, E)
Fort Ross trigonoscuta weevil (SP, E)
Antioch weevil (SP, E)
Mono Lake hygrotus diving beetle (SP, E)
Valley mydas fly (SP, E)
Antioch robber fly (SP, E)
Volutine Stonemyian tabanid fly (SP, E)
Pheres blue butterfly (SSP, E)
Sthenele wood nymphy butterfly (SSP, E)
Atossa fritillary butterfly (SSP, E)
Strohbeen's parnassian butterfly (SSP, E)
Xerxes blue butterfly (SP, E)
Castle Lake rhyacophilan caddisfly (SP, E)
Yellow-banded andrenid bee (SSP, E)
Antioch sphecid wasp (SP, E)

Sources: Remsen 1978, California Department of Fish and Game 1983, U. S. Fish and Wildlife Service 1985, Williams 1986, Gould, Schlorff, Singleton, Weidlein pers. comms.

[a] Status codes are: SP = species; SSP = subspecies; E = species or subspecies is extinct throughout its range; E-CA = species or subspecies is extirpated within California, but still exists outside the state; E-CA/B = extirpated as a breeder within California, but still occurs during nonbreeding periods.

[b] Extinct in the wild, but living in captivity.

[c] Many more species of insects and other invertebrates have probably become extinct in California without anyone knowing of their existence. This list includes only recently noted extinctions.

Although this is a small percentage of the flora, it represents 118 species, 50 percent more than all listed vertebrates.

As previously noted, many plant and animal species have been severely reduced and are threatened with further reduction, but have not yet been officially designated by either the state or federal governments as threatened or endangered. Adding these potentially threatened or endangered species to those that are already listed (Table 3), we find that a third of California's mammals and nearly a quarter of our birds may be eventually threatened with extinction in the state. A third of the state's reptile and amphibian species, and 40 percent of the freshwater fish species are in similar danger. As many as 600, or 12 percent of California's native tree, shrub, and wildflower species could become imperiled if current trends continue.

The extent to which many species within lesser-known groups of plants and animals are endangered cannot be determined because many species remain undescribed or poorly known. For example, 103 insects in California are either listed as threatened or endangered or are identified as possibly qualifying for listing. This is probably an extreme underestimate, however, because perhaps 2,000-7,000 species of insects are endemic to California (Hogue pers. comm., Pyle 1976, 1983). No one can even roughly estimate how many native lichens, spiders, or mollusks are in danger of vanishing unnoticed.

Distribution of Species. Threatened or endangered plants and animals occur in every one of California's 58 counties. Although many individual species have highly restricted ranges or are confined to one declining habitat type, California's variety and abundance of rare species and unusual habitats is so great that virtually every geographical division of the state supports rare species. The distribution of known occurrences for California's rarest mammals, birds, and plants is shown in Figures 2, 3, and 4. Additional occurrences will be discovered as field research and documentation continues.

Although rare species as a group are widely distributed, many individual species have very localized ranges. For example, of 710 plant taxa (i.e., species, subspecies, and varieties) inventoried by NDBB, 80 are known from only one site in the state. Another 311 taxa are known only from sites within a 5-square-mile area. An additional 187 species are restricted to a 50-square-mile area (Ellison pers. comm.). These figures suggest that many threatened, endangered, and rare plants could easily be extirpated by localized disturbances due to their restricted ranges and small numbers.

Status of Listed Species. One objective of listing a species as threatened or endangered is to focus attention on the species to encourage its recovery. As required under the California Endangered Species Act, the California Department of Fish and Game (1987c) prepared a status summary for individual

Table 3. Numbers of Native and Threatened or Endangered Species in California

	Mammals	Birds	Reptiles	Amphibians	Freshwater Fishes	Vascular Plants
Native Species[a]	214	349	74	45	66	5,143
Listed Threatened or Endangered Species[b]						
Full Species	15	5	4	7	10	84
Species with Listed Subspecies	7	15	8	1	8	34
Total	22	20	12	8	18	118
Percent of Native Species	10%	6%	16%	18%	27%	2%
Other Species That May Qualify for Listing[c]						
Full Species	12	58	8	5	3	349
Species with Potentially Qualifying Subspecies	36	4	3	5	6	138
Total	48	62	11	10	9	487
Percent of Native Species	22%	18%	15%	22%	14%	9%
Total Number of Full Species or Species with Subspecies Listed, or with Potential for Listing	70	82	23	18	27	605
Percent of Native Species	33%	23%	31%	40%	41%	12%

NOTES:

[a] See footnote "a" in Table 1 for sources.

[b] Listed as Threatened or Endangered under state or federal Endangered Species Acts. Separate counts are given for listed full species and species containing one or more listed subspecies or varieties. Source for animals: California Department of Fish and Game (1987a); source for plants: California Department of Fish and Game 1987b).

[c] Includes 1) animals and plants that are likely to meet criteria for state or federal listing, but for which listing packages have not been prepared and 2) animals and plants that have declined substantially within the state and are identified as USFWS Candidates for listing or DFG Species of Special Concern. Separate counts are given for qualifying full species and for species containing one or more qualifying subspecies or varieties. Source for animals: California Department of Fish and Game (1987a) Remsen 1978, Williams 1986; sources for plants: California Department of Fish and Game (1987b); U. S. Fish and Wildlife Service (50 Federal Register 39526, Spetember 17, 1985).

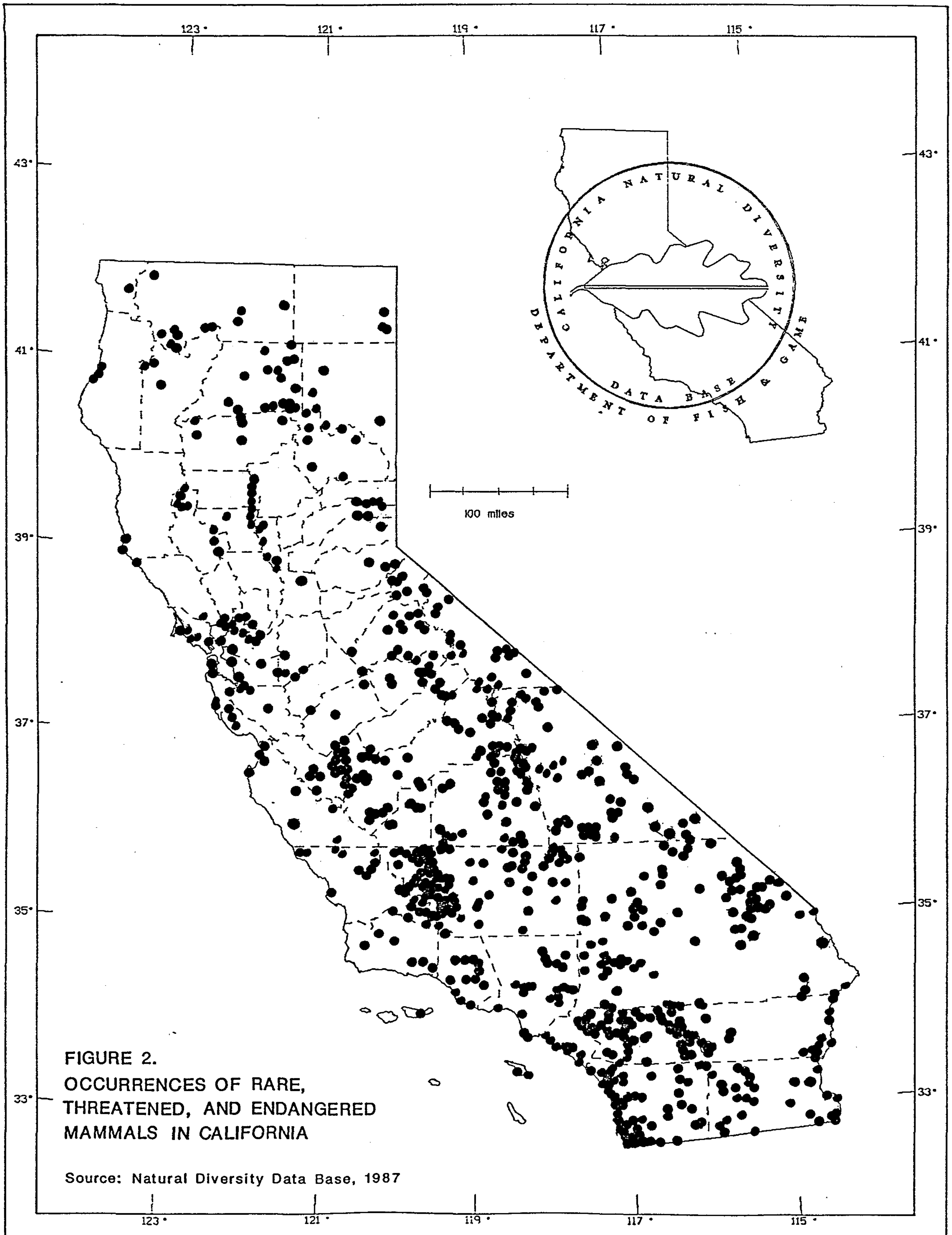

FIGURE 2.
OCCURRENCES OF RARE, THREATENED, AND ENDANGERED MAMMALS IN CALIFORNIA

Source: Natural Diversity Data Base, 1987

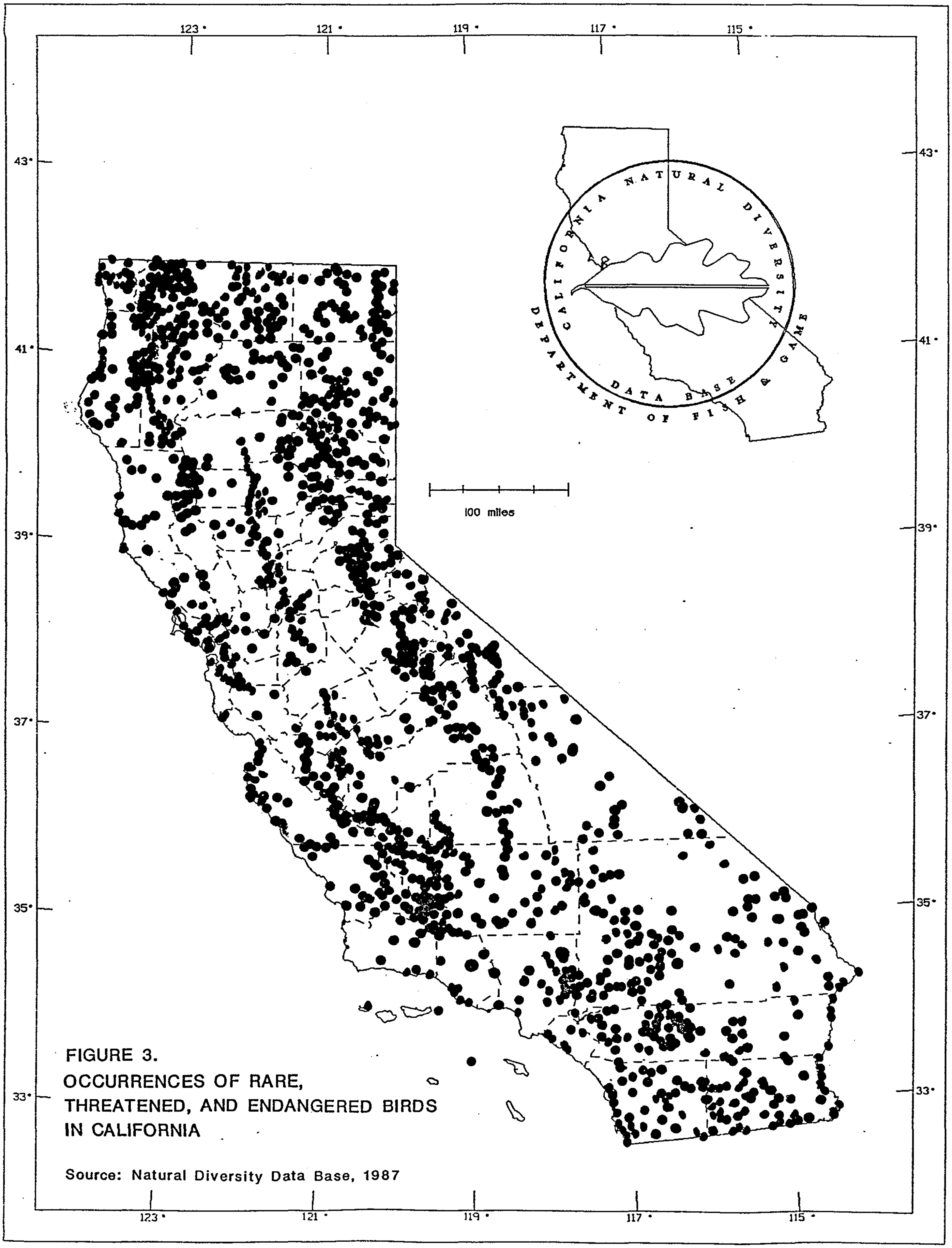

FIGURE 3.
OCCURRENCES OF RARE, THREATENED, AND ENDANGERED BIRDS IN CALIFORNIA

Source: Natural Diversity Data Base, 1987

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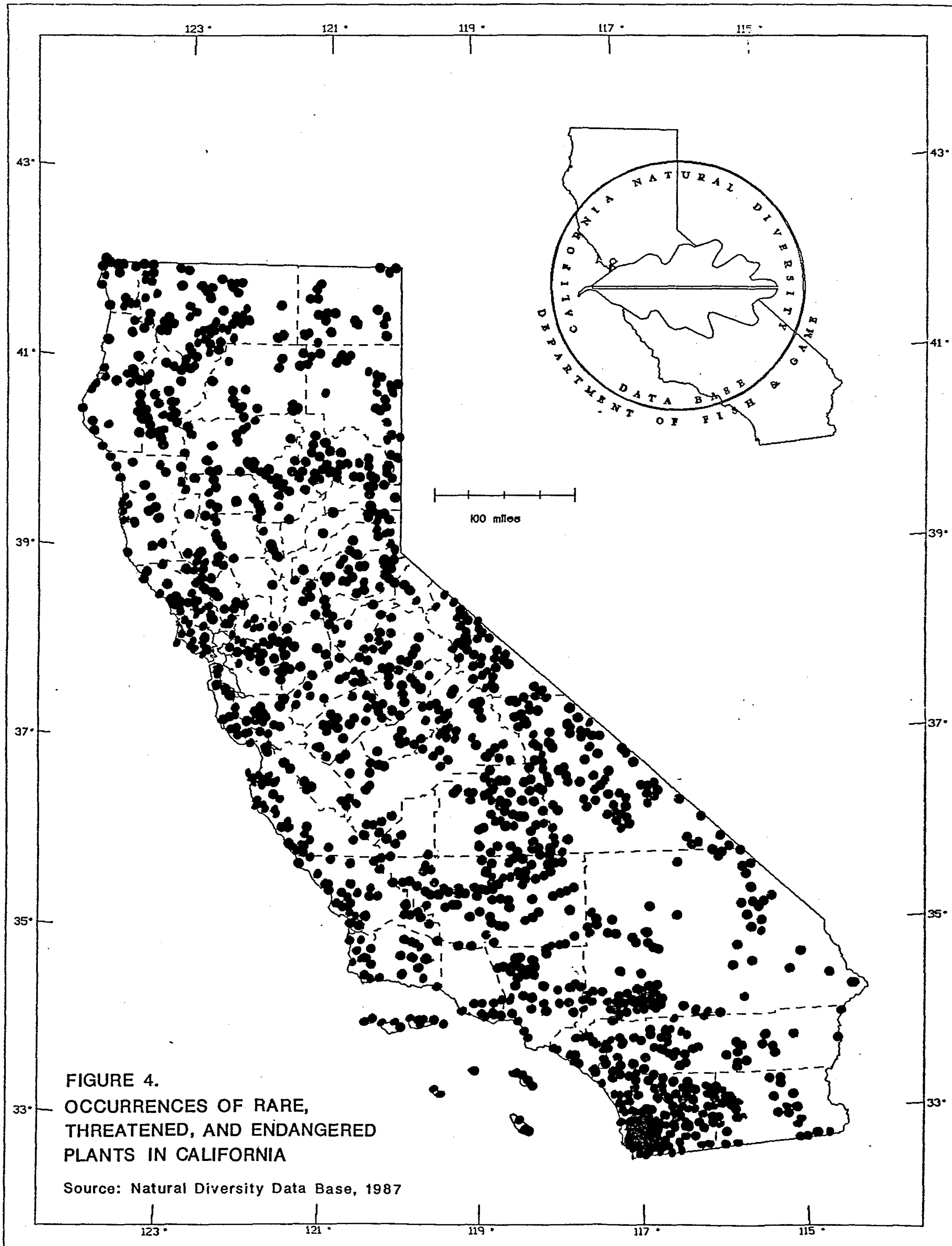

FIGURE 4.
OCCURRENCES OF RARE, THREATENED, AND ENDANGERED PLANTS IN CALIFORNIA

Source: Natural Diversity Data Base, 1987 plants and animals listed by the state. A summary of species trends derived from this report shows that most listed species are either stable or are continuing to decline in the state (Table 4).

Declines of state- and federal-listed species are occurring for many different reasons. The major causes for declines are habitat destruction and degradation (California Department of Fish and Game 1987c). Both the state and federal endangered species acts legally prevent direct taking (i.e., killing, injuring) of listed species (except the state law excludes plants). The federal law also defines taking to include altering or eliminating the habitat of an endangered species, even on private lands; in contrast, the state endangered species act gives no protection to habitats that are degraded or eliminated by private actions on private lands.

The continued decline in many threatened and endangered species indicates that many biological and institutional obstacles continue to prevent full protection and recovery of declining species. Major efforts have been successful in initiating the recovery of species with high public interest, such as the bald eagle, peregrine falcon, and California bighorn sheep (California Department of Fish and Game 1987c). Other more obscure species with very limited distributions (especially certain endemic plants) have been greatly helped through purchase of remaining habitats and increased protective management. Unfortunately, however, the recovery of most species is still hampered by both biological limitations (e.g., permanent loss of habitats, establishment of competitors or predators, and inherent difficulties associated with small, scattered populations) and institutional problems (e.g., lack of funds, limited legal authority).

Threatened Habitats

Habitat losses through conversion to other land uses is the major cause of species endangerment. Because of the dependence of species upon habitats, an analysis of the magnitude and patterns of habitat losses provides important insights into the loss of natural diversity. Habitat threats are analyzed at two levels. First, we evaluate acreage losses in the major, broadly defined habitat groupings in the state. Second, we analyze the extent to which various types of specific plant communities are threatened in the state.

Losses of Major Habitats. Declines in natural diversity result from large scale losses of major habitats. Unfortunately, the lack of early data on the original extent of most native habitats prevents us from precisely determining the magnitude of losses to most major habitat types. Rough estimates for certain habitat types, including riparian forests and wetlands, are summarized in Table 5.

Table 4. Current Trends in Populations and Habitats of State-Listed Threatened and Endangered Species in California[a]

	Increasing	Stable	Decreasing	Unknown	Total
Animals					
Number of Species	5	27	26	5	63[b]
Percent	8	43	41	8	100
Plants					
Number of Species	13	40	106[c]	25	184
Percent	7	22	58	14	101[d]
Total					
Number of Species	18	67	132	30	247
Percent	7	27	53	12	99[d]

[a] Table does not include federally endangered species not listed by California.

[b] Totals do not include three fish species presumed extinct.

[c] For plants, the "decreasing" category includes species that are actively threatened by proposed projects.

[d] Percentage totals differ from 100 due to rounding.

Source: California Department of Fish and Game (1987).

Table 5. Estimated Losses of Certain Habitats Since the Early 1800s

Habitat	Estimated Pre-1850 Acreage	Current Acreage	Percent Lost
Central Valley Riparian Woodland[a]	921,000	102,000	89
Coastal Wetlands[b]	253,000	51,000	80
Interior Wetlands[c]	4,000,000	250,000	94
Central Valley Vernal Pools[d]	4,150,000	1,380,000	66

[a] Katibah 1984. Current acreage is a generous estimate including many heavily disturbed areas. Loss of undisturbed riparian woodland probably exceeds 99 percent.

[b] ESA/Madrone 1982. Includes San Francisco Bay and south coast regions for which data are fairly accurate.

[c] ESA/Madrone 1982. Current acreage includes large areas of artificial wetland habitat that contain no natural wetland plant communities. Loss of natural interior wetland communities probably exceeds 99 percent.

[d] Holland 1978. Acreages represent areas containing or potentially containing vernal pools. Loss of individual pools may be as great as 75-80 percent.

More precise estimates of acreage losses for most habitats are available for the period 1945-1980 from data developed by the staff of the California Department of Forestry and Fire Protection's (CDF) Forest and Rangeland Resources Assessment Program (Tosta pers. comm.) (Table 6). These losses include only acreages completely lost to development and agricultural conversion but do not include effects of land uses that have degraded habitats. These data show that over onefourth of the grassland habitat in the state has been eliminated in the last 35 years. The coastal scrub habitat has declined by over 300,000 acres, or 11 percent, of its extent in 1945. The valley foothill hardwood (i.e., oak woodland) habitat has lost nearly a half-million acres, 7 percent of the 1955 total.

The closed cone pine and cypress forests of the California coast have been reduced by 5 percent, while the redwood forest has lost 62,000 acres, or 4 percent of its 1955 total. Other major habitat losses include chaparral, great basin shrub, and the ponderosa-Jeffrey pine forests, which have been reduced by over 2 percent. Considering all of California's habitats, over 4.8 million acres were eliminated during the 35 years between 1945 and 1980, an average loss rate of over 140,000 acres per year.

Threats to Natural Communities. The staff of the NDDB (Holland 1986, Ellison 1984) has identified 380 different natural communities in California and also has determined that 178 communities (47 percent) are of high inventory priority because they are rare or imperiled with losses (Appendix 4). We have summarized the number of total and imperiled communities in various habitat groups (Table 7). This summary indicates that all or nearly all marsh, riparian and bottomland, and sand dune habitats and four-fifths of herbaceous, estuary, lagoon, and bay communities are rare or threatened. A quarter to half of the scrub and chaparral, woodland, forest, lake and pond, and stream communities are uncommon or threatened. Only the alpine and shore and intertidal community groups contain no rare communities.

Many of the rare natural communities have always been rare in California. Human activities have reduced many others from common to rare. Both types of rare communities require careful attention to ensure that they are not completely eliminated in the near future.

Monitoring the Status of Natural Diversity

Detailed data on a region's threatened natural diversity are often difficult to obtain. Fortunately, California has many hundreds of professional and amateur biologists who devote time, energy, and expense to looking for and documenting rare and threatened species and habitats. Keeping track of the locations

Table 6. Acres of Terrestrial Habitat Types, and Amounts Lost Since 1945 in California

Habitat Groupings[a]	Current Total Acres (in 1000s)	Acres Lost 1945–1980 (in 1000s)	Percent of Acres Lost 1945–1980
Closed cone pine-cypress	78	4	5
Ponderosa and Jeffrey pine	3,351	80	1
Montane hardwood, and montane hardwood-conifer	3,205	27	1
Mixed conifer	9,268	41	<1
Douglas-fir	1,772	2	<1
Redwood	1,570	62	4
Red fir	1,906	1	<1
Lodgepole-subalpine conifer	980	1	<1
Valley foothill hardwood	7,363	591	7
Montane and valley riparian	135	N/A[b]	—
Juniper and pinyon juniper	2,932	29	1
Chaparral (chamise-redshank, mixed, and montane)	8,801	203	2
Alpine dwarf shrub	206	<1	<1[c]
Great basin shrub (big sagebrush, low sage, and bitterbrush)	7,637	216	3
Coastal scrub	2,507	310	11
Annual and perennial grasslands	8,743	2,994	26
Desert shrub (Joshua tree, desert riparian, alkali scrub, desert succulent scrub, desert scrub, desert wash)	21,278	300	1
Fresh emergent wetland	576	N/A	—
Total	82,308	4,861	5.8

[a] Habitat names follow Mayer and Laudenslayer (in press), with some habitats combined.
[b] No statewide acreage losses were determined in this assessment.
[c] Alpine dwarf shrub acreages lost since 1955 are rough estimates.
Source: Tosta pers. comm.

Table 7. Numbers of Native and Rare or Threatened Natural Communities in California

Type of Community	Total Number of Communities Recognized	Number of Rare or Threatened Communities[a]	Percent of Communities Rare or Threatened
Marsh	14	14	100
Riparian and Bottomland	19	18	95
Sand Dune	12	11	92
Herbaceous	27	22	82
Estuary, Lagoon, and Embayment	9	7	78
Stream	63	34	54
Forest	62	30	48
Lake and Pond	44	15	34
Woodland	32	9	28
Scrub and Chaparral	72	18	25
Alpine	10	0	0
Shore and Intertidal	16	0	0
Totals	380	178	47

[a] See Appendix 4 for a complete listing of rare and threatened natural communities in California.

Source: Holland (1986) and Ellison (1984).

and status of species and communities is essential to sound conservation and development planning in California. Most of the collected data are provided to two statewide natural diversity monitoring programs.

The California Natural Diversity Data Base. NDDB is part of the Nongame-Heritage Program of DFG. NDDB has computerized 16,000 occurrences of nearly 1,100 of California's most rare, threatened, and endangered plants, animals, and natural communities (Shevock and Hennessy 1987, Ellison pers. comm). Although this may seem like a large number of records, it averages only 15 records per rare species or habitat. Many species are known from only one or several locations. NDDB provides rare species data to agency staff, legislators, planners, land managers, scientists, and the public. This information is used throughout the state to aid in protecting, managing, and assessing impacts to the state's rarest living resources.

The California Native Plant Society Inventory. A closely related monitoring effort is operated by the Rare Plant Program of the California Native Plant Society (CNPS), a nonprofit conservation organization (Smith 1987). CNPS cooperates closely with NDDB, but unlike NDDB, focuses exclusively on plants, monitors many species that are not currently threatened or are inadequately known, and draws upon a large, statewide network of active volunteers. CNPS publishes the "Inventory of Rare and Endangered Vascular Plants in California," (Smith and York 1984); the fourth edition of this book will appear in late 1987 or early 1988. This document is one of the most accurate and detailed inventories of its kind in the world, and is an essential tool for land use planning and environmental impact assessment in California.

Examples of Losses and Declines in California's Species

Extinctions Caused by Man

California Grizzly Bear. One of California's most impressive animals was the grizzly bear, the largest carnivore in North America. The grizzly bear was originally common throughout the state except in the southern deserts and the Great Basin. Early market hunters, ranchers, miners, and other pioneers frequently killed the bears for sport and to prevent farm and livestock depredation (Grinnell et al. 1937). The grizzly's food supply was also greatly reduced by market hunting and fisheries decline due to habitat degradation and over-fishing. The California grizzly declined dramatically in the late 1800s and early 1900s, and the last known individual was killed in the Sierra Nevada, in Tulare County, in 1922 (Ingles 1965).

Sharp-tailed Grouse. The disappearance of the sharp-tailed grouse from California illustrates the subtle way in which habitat changes have caused the extinction or decline of many species. This chicken-sized bird was common in the extensive grasslands that once occupied the Modoc Plateau of northeastern California. After Captain Jack and the Modoc Indians were subdued in the 1880s, excessive livestock grazing degraded the soils and eliminated most of the perennial grasses, allowing the invasion of sagebrush and other shrubs that provided little food for the sharp-tailed grouse (Hubbard 1965). The sharp-tailed grouse was last seen in 1915, barely three decades after degradation of its habitat began (Mailliard 1927).

Enterprise Clarkia and Laurel Hill Manzanita. The Enterprise clarkia was first described in 1971 from specimens collected several years earlier near the Feather River (Small 1971). It was last seen just prior to disappearing under the waters of Oroville Reservoir in 1968 (Smith and York 1984). The Laurel Hill manzanita was once common on the San Francisco Peninsula, but has not been seen in the wild since 1968. It was eliminated by development of the steep hills that have now become San Francisco's trademark. It survives in cultivation, although in such small numbers that its genetic variation is probably depleted.

Declining Species

Extinctions grasp our attention because they are the most dramatic and tragic of all losses of natural diversity. Important as these losses are, we should be even more concerned about living species that are becoming endangered in California. Disappearing populations and diminishing geographic ranges often escape our notice until the species are genuinely in peril. Many historic occurrences of thousands of California species and communities are now completely gone. The following examples illustrate some of the species that have declined most dramatically.

California Condor. The condor is one of the most critically endangered species in North America. Until about 1870, these birds were common throughout much of the state. By 1943, only about 100 individuals remained in a much reduced range (Grinnell and Miller 1944, Koford 1953). Since then, their population has declined precipitously (Figure 5). This decline has resulted from several specific causes, but all threats ultimately are associated with loss of undisturbed native habitat. In this sense, the condor may represent the proverbial mine canary, an indicator that is warning us of the potential effects of further habitat losses.

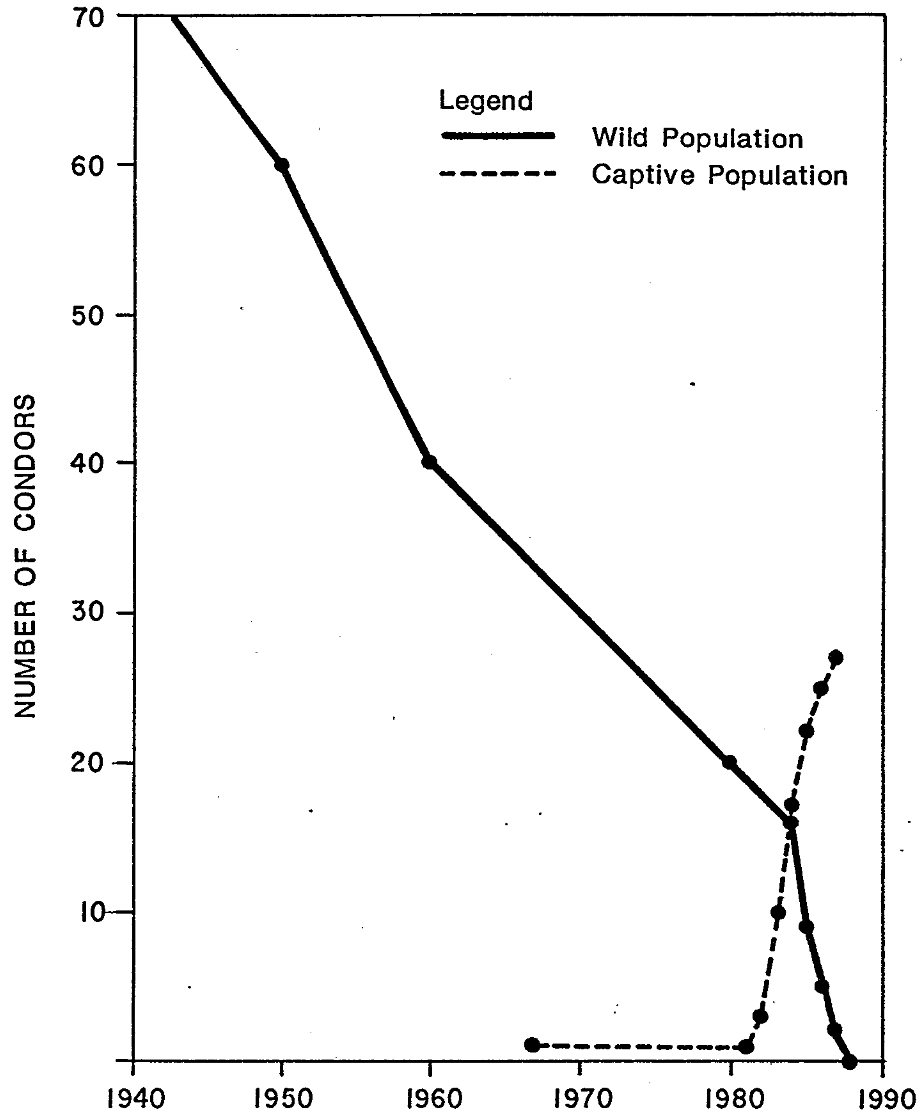

FIGURE 5. POPULATION OF CALIFORNIA CONDORS

Sources: Koford (1953), Miller et al. (1965), Snyder and Johnson (1985), Condor Research Center (Sanders pers. comm.)

An intensive captive breeding program was initiated for the condor in the 1980s as a last-ditch effort to save the species. On April 19, 1987, the last wild California condor was captured and removed from the wild, ending, at least temporarily, this species' reign as the largest wild bird in North America. As of June 1987, 27 condors were living in captivity (Sanders pers. comm). The species' successful return to the wild depends on both success in increasing the population through the breeding program, and protecting sufficient habitat to permit survival of future reintroduced birds.

San Joaquin Kit Fox. The San Joaquin kit fox once inhabited native semiarid habitats throughout the San Joaquin Valley, and in Monterey, Santa Clara, San Luis Obispo and Santa Barbara Counties (Grinnell et al. 1937, Morrell 1975, O'Farrell 1983). By 1930, Grinnell and his coworkers reported that the kit fox range in the San Joaquin Valley had been reduced to arid portions of the western and southern parts of the valley and where agricultural development had not yet occurred. Subsequent development of the state and federal water projects brought increased agricultural conversion of kit fox habitat in the 1960s and 1970s.

In 1975, the total kit fox population was estimated at about 7,000, indicating a 20-43 percent population decline in the last 50 years (O'Farrell 1983). The greatest threat to the kit fox is the continued loss of habitat to agricultural, urban, industrial, energy, and mineral development in the San Joaquin Valley (O'Farrell 1983). Road kills, illegal shooting, trapping, and rodent poisoning also may be significant factors in the species' decline (O'Farrell 1983).

Spring-Run Chinook Salmon. The spring-run chinook salmon is a distinctive form of the chinook salmon that was once extremely abundant in California's Klamath, Sacramento, and San Joaquin River systems. This salmon group is distinguished by a unique life history. Adult spring-run fish leave the ocean to return to spawning streams in March to May. They ascend their natal streams during late spring and take refuge during the summer in cool water at mid- to high-elevation pools where they remain until they spawn in the early fall (Marcotte 1984).

Before the gold rush, every large tributary in the Klamath system and Central Valley supported a spring-run of chinook salmon. This chinook run formed the backbone of the commercial salmon fishery in California in the 1800s. Today, these runs are reduced to less than 5 percent of their historic numbers (Gerstung 1982). The blocking of access to ancestral summer holding pools and spawning sites by dams has been the major cause of the decline. Entire runs were eliminated from the upper Klamath River by Copco Dam. Shasta Dam reduced spawning habitat in the entire Sacramento system by 50 percent. Friant Dam on the San Joaquin River eliminated the entire run of 20,000 to 30,000 salmon (Skinner 1958). Dams on many other streams eliminated smaller runs. Other factors contributing to the decline include habitat degradation due to mining, logging, and major floods, early overfishing, and water diversion for agriculture.

Today, very small numbers of spring-run fish remain in smaller tributaries of the Klamath River (including South Fork Trinity, New River, and Canyon Creek) and the Sacramento River (including Deer, Mill, and Butte Creeks) (Marcotte 1984). Most of these runs are threatened by existing water diversions and proposed hydroelectric developments. Small runs have colonized new habitat created by release of cool waters from Shasta Dam on the Sacramento River and Lewiston Dam on the Trinity River. These runs are threatened by unfavorable water release schedules, instream diversions, and possibly by hybridization with other chinook salmon stocks.

Recovering Species

Protection and restoration efforts have successfully halted or reversed dramatic declines in some California species. The following examples describe species that were greatly reduced, and in some cases nearly eliminated, in California. Although they will never be as abundant as they once were, careful management has permitted these species to increase and to securely occupy portions of their former ranges. These examples show us what can be achieved by concerted management effort.

Bighorn Sheep. California supports three subspecies of the bighorn sheep, whose numbers altogether probably never exceeded 10,000 individuals (Bleich pers. comm.). Two of the subspecies are threatened in the state, the peninsular bighorn sheep of Anza-Borrego State Park and surrounding area in southern California, and the California bighorn sheep of the southern Sierra and Warner Mountains. All bighorn sheep subspecies require steep, mountainous terrain (Dasmann 1965).

The major factors that reduced bighorn populations were heavy grazing in mountain areas during the last century, transfer of disease from domestic livestock, appropriation of water from desert springs by miners and ranchers, and poaching (Dasmann 1965). The last California bighorn on Mt. Shasta was killed in 1877; they were extirpated from the Yosemite region in about 1900 and from Modoc and Siskiyou Counties in the 1920s (Dasmann 1965). Many desert bighorn herds were extirpated between 1948 and 1968 due to a variety of factors, including competition with feral burros and livestock, introduced diseases, and human disturbance (Weaver 1982).

The three subspecies of California bighorns have made a substantial recovery in recent years, following protection from poaching, reduced competition from domestic livestock, water development, and successful reintroduction programs. In 1965, only 2,000-2,500 bighorn sheep were believed to occur statewide; by 1987, the total population was estimated at 5,000 individuals including about 750 Peninsula bighorns and 250 California bighorns (Bleich pers. comm.). Recent reintroductions have established new populations in the Warner Mountains, the Sierra Nevada near Yosemite, and in various desert mountains (Camilleri and Thayer 1982, Bleich and Hargis pers. comms.).

Tule Elk. Vast herds of tule elk once roamed the grasslands and marshes throughout central California. Few data are available on the total size of the historic tule elk population, but the state's population may have numbered 500,000 individuals prior to European settlement (McCullough 1971). Competition with livestock; hunting for meat, hide, and tallow; and land development by settlers reduced tule elk populations to perhaps as few as two individuals by 1870. In the late 1800s and early 1900s, tule elk were protected by establishing private and then public refuges and by transplanting the growing population to dispersed locations. In March 1987, California's entire population numbered 1,975 individuals living on 18 separate refuges (Mansfield pers. comm.). These populations are carefully managed to maintain stable numbers on the individual refuges. Historic and current distributions of tule elk in California are shown in Figure 6.

Pronghorn Antelope. No one knows how many pronghorn antelope lived in California prior to European settlement. Perhaps 500,000 individuals lived over most of the state (Pyshora 1981). Early market hunting, competition from livestock, and land conversion to agriculture and urban areas had reduced the pronghorn population and range dramatically by the early 1900s (Dasmann 1965). Pronghorn were completely eliminated from the Central Valley, which originally supported the densest populations in the state. By 1923, perhaps only 1,000 animals remained in Lassen, Modoc, and Siskiyou Counties in northeastern California (Figure 6).

Careful management and reintroduction of pronghorn to portions of their former range have allowed their population to increase. The current statewide population is about 7,350, with the majority of animals occurring in the northeastern counties (Vincenty pers. comm.). A 1987 reintroduction in Kern County has returned the pronghorn to southern California.

Examples of Declining Habitats

Habitat Loss. Elimination of habitat is the most direct cause of most extinctions, extirpations, and species endangerment. Nearly every habitat and natural community in California has been reduced in quantity and quality since presettlement times. Although not legally designated, half of California's terrestrial natural communities and 40 percent of the aquatic communities are rare or threatened (Holland 1986, Ellison 1984).

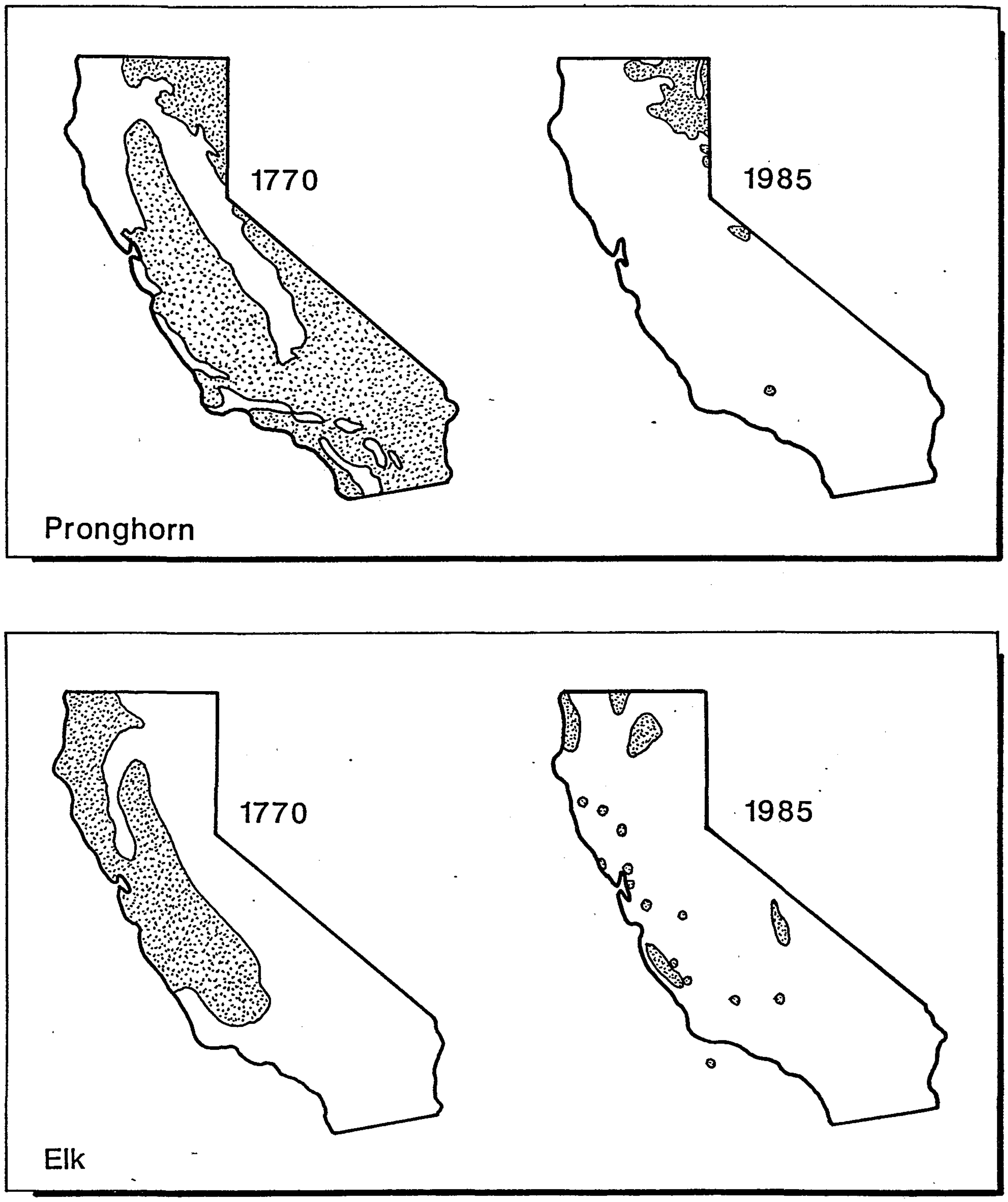

FIGURE 6. RANGE CHANGES OF PRONGHORN AND ELK IN CALIFORNIA

Source: Dasmann 1964, Zeiner et al. in press

Many types of communities are in serious danger of disappearing completely, along with species unique to them. Some of the most striking examples are discussed below, and several are treated in greater detail in Chapter 5, "Case Studies."

Coastal Wetlands. Wetlands are a prominent feature of bays and river mouths along the California coast. They have extremely high value as natural communities, providing fish and wildlife habitat, nutrients and energy sources for aquatic food chains, sediment trapping, waste assimilation, storm and floodwater storage, shoreline protection, and recreational and educational opportunities. Most of these wetlands have been filled, dredged, or diked, and converted to farms, pastures, harbors, marinas, cities, and garbage dumps.

Tidal marshes once occupied more than 300 square miles around the margins of San Francisco, San Pablo, and Suisun Bays. Today, only 19 percent of this remains. Another 29 percent, mostly in Suisun Marsh, is diked and managed for wildlife habitat (Jones & Stokes Associates 1979, Gill and Buckman 1974). Smaller, yet equally important wetlands in many other bays have suffered greater losses. San Diego Bay, where gray whales once bore their young, contains as little as 10-15 percent of its original salt marsh (Browning and Speth 1973, Mudie 1970). In Humboldt Bay, less than 9 percent of the original marsh vegetation remains (MacDonald 1977).

Riparian Woodlands. The mountains, hills, and valleys of California contain tens of thousands of miles of rivers, streams, and sloughs. The banks and floodplains of these waterways support riparian vegetation, which depends on the adjacent waters for survival. Riparian woodland and shrub communities provide one of the richest wildlife habitats in the state. Early in the last century, the great river systems of the Sacramento and San Joaquin Valleys supported an estimated 920,000 acres of riparian vegetation (Katibah 1984).

During the last 140 years, riparian trees were felled to fuel steamers and provide firewood for communities along the Sacramento and San Joaquin Rivers; fertile floodplains were cleared to grow crops; rejuvenating floodwaters were confined between leves; banks were cleared to make room for waterfront industries; and now many of these banks are being armored with boulders and concrete to keep the rivers from meandering into the domain of modern man. Today, only 102,000 acres remain, less than 11 percent of the Central Valley's original riparian vegetation. Much of this remainder has been substantially degraded; at most, only 1 percent of the original habitat remains in nearly pristine condition (Katibah 1984).

Native Grasslands. The decline of native grasslands due to agricultural conversion, livestock grazing, and invasion by exotic plants represents one of the most dramatic losses among all of California's unique natural communities. Native grasslands were originally dominated by perennial bunchgrasses such as purple needlegrass, nodding needlegrass, blue wildrye, pine bluegrass, and deergrass. Populations of spring wild-flowers were spectacular. Nearly a quarter of the state was once covered with perennial grasslands. But as grazing pressure from settlers' livestock increased, dozens of aggressive annual grasses from Europe and Asia flourished at the expense of the less competitive native bunchgrasses. Today, only a tiny fraction of grasslands dominated by native species remains, at most only a tenth of one percent (Barry 1972). The golden summer grasslands of California, often used to symbolize the state and its riches, in fact represent one of the greatest losses of indigenous natural diversity in western America.

Habitat Degradation. Many examples of important and rare habitats that remain in California have been degraded by various land uses. Activities such as livestock grazing, logging, fire control, application of toxic chemicals, water diversion, and recreational use often change the character of habitats and make them less suitable for certain plant and animal species. Habitat degradation often occurs slowly so that its effects, even when substantial, are not evident over the short-term.

Chaparral. One example of large scale habitat degradation in California is the effect of suppressing fire in chaparral habitats. Under natural conditions, these shrub habitats burned regularly, producing a mosaic of different aged stands of vegetation (Hanes 1977). Through fire prevention and control activities, man has prevented regular burning of chaparral in many areas. As a result, these areas have grown old, decadent, and, in some cases, unsuitable for some plant and animal species that were formerly abundant. These habitats have also become powder kegs, containing high accumulations of dead fuels that eventually result in large, destructive conflagrations.

Under the recent Chaparral Management Program, CDF is attempting to burn more decadent brushlands on a regular basis to increase productivity and reduce fire danger. With careful consideration of natural biological values (e.g., Parker 1987), this program has potential to restore large areas of chaparral habitat.

Conifer Forests. Timber management activities on both private and public forest lands have changed the character of many forest habitats. On California's national forests, old growth forest habitats are estimated to have declined by 50 percent since 1900, from 4 million to 2 million acres; up to 700,000 additional acres could be lost by the year 2035 (Laudenslayer 1985). The harvest of old growth forest stands for lumber and the resulting fragmentation of remaining stands have prompted major concerns over the future of the spotted owl and other species that depend on this habitat (Raphael and Barrett 1983, Guiterrez and Carey 1985, Norse et al. 1986, Dawson et al.

1987). Habitat for many wildlife and plant species is also being altered by road building and timber management practices such as planting of single species in regenerated stands, removing of vegetation that competes with commercial species (using herbicides and other techniques), and eliminating dead and injured trees (Thomas 1979, Raphael and White 1978).

Other examples of disturbances that have altered natural habitats include fire suppression in forested habitats, grazing and introduction of nonnative species in oak woodlands (see Chapter 5), water diversion from streams, and recreational vehicle use at beaches and dunes.

Causes of Decline in California's Natural Diversity

The imperiled status of natural diversity in California is a combined result of many different human activities. The important common feature among these activities is the loss or degradation of habitat for native species. In the pursuit of food, shelter, livelihood, and pleasure, Californians have occupied and modified much of the state's wildlands so that many areas now support few or none of our native plants and animals. Figure 7 illustrates the declines that have occurred in wetlands and riparian woodlands while human population and development pressures in California have risen.

Direct Losses

As previously described, natural habitats have been destroyed in many areas by converting land to agriculture, flooding with reservoirs, draining and filling wetlands, channelizing rivers, disposing of wastes in landfills, developing urban areas, and mining. Many of our remaining habitats have been degraded by logging, grazing, fire suppression, road construction, stream diversion, offroad vehicle recreation, military training maneuvers, and the proliferation of nonnative plants, insects, and feral animals. Wildlife and plant populations have also been disturbed or reduced by the more generalized effects of air and water pollution, fencing, noise, lights, power lines, traffic, and many other components of the human environment. Examples of how habitat loss and degradation have affected certain habitats are discussed in Chapter 5, "Case Studies."

Cumulative Impacts

Cumulative effects can impact species and communities in several ways. Incrementally small impacts may have additive or overlapping effects and thus become collectively severe. Relatively minor actions may multiply or accumulate over time or trigger events with more severe impacts (National Research Council 1986).

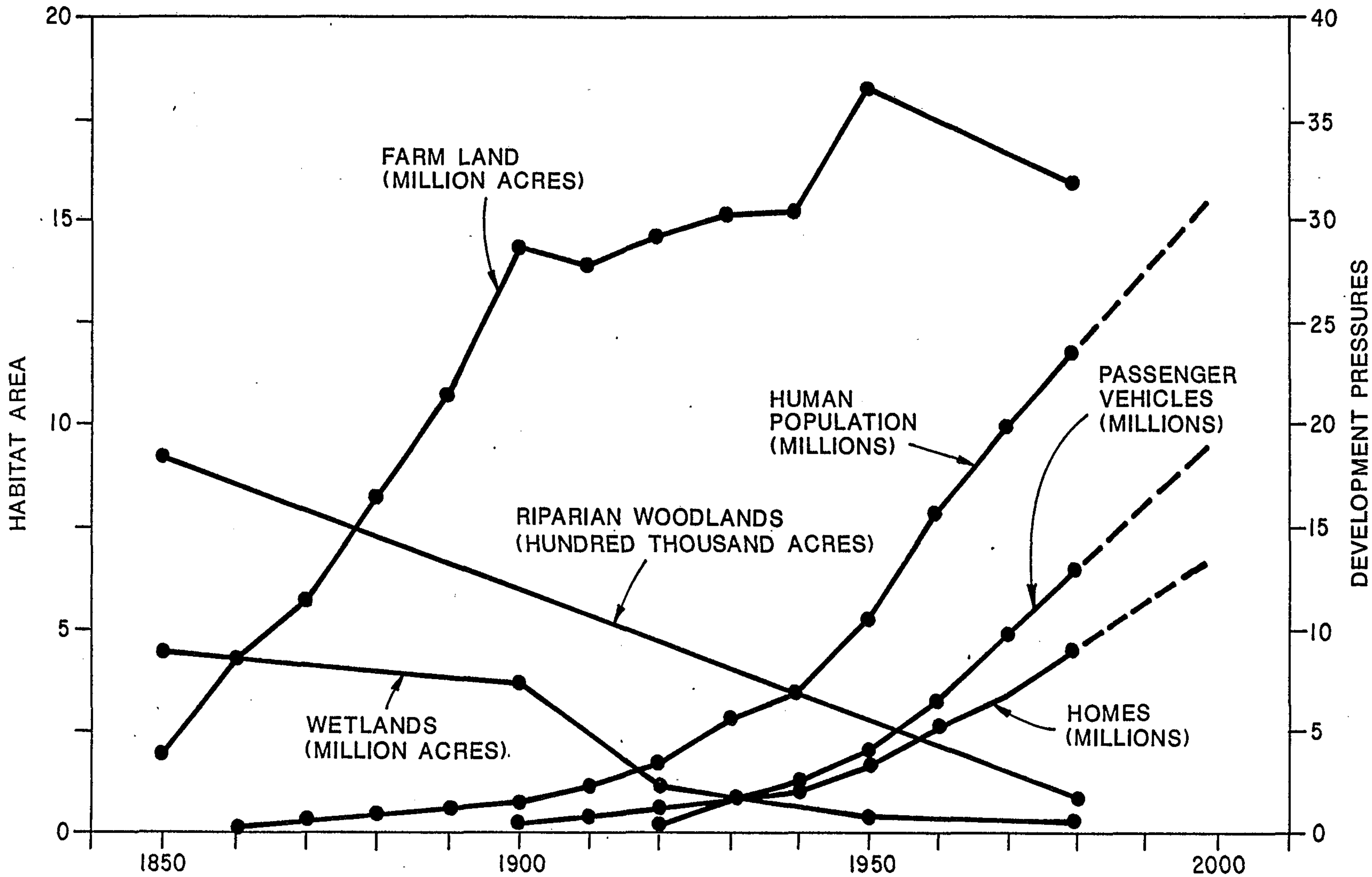

FIGURE 7. COMPARISON OF HABITAT LOSSES AND RELATED DEVELOPMENT PRESSURES IN CALIFORNIA SINCE 1850

Sources: California Department of Finance (1970, 1971, 1981, 1983, 1986); U.S. Fish and Wildlife Service (1978), Katibah (1984).

A recent example of a cumulative impact was the poisoning of waterfowl by accumulations of toxic selenium in pondwater at Kesterson National Wildlife Refuge (NWR) in Merced County. The situation at Kesterson was not of local origin; selenium-laden waters were brought to Kesterson via the San Luis Drain from the Westlands Water District, more than 80 miles to the south. In the Westlands area, irrigation water from the federal Central Valley Project was applied for irrigation, and trace amounts of selenium leached from naturally seleniferous soils into irrigation water that was drained through subterranean pipes. Over the years this selenium accumulated in bottom sediments at Kesterson. Eventually, high enough concentrations of selenium were mobilized from these sediments into the food chain to cause severe toxicity in a variety of wildlife species (Ohlendorf et al. 1986, U. S. Bureau of Reclamation 1986).

Another example is the complex manner in which habitat disturbance has increased populations of adaptable bird species that are detrimental to sensitive species. The brown-headed cowbird, a brood parasite that lays its eggs in other birds' nests, was originally native to California but its numbers were low and distribution localized (Ginnell and Miller 1944). The cowbird has increased its range and numbers spectacularly in response to increased foods provided by livestock, agriculture, and human populations.

In the 1930s, the cowbird spread into the Central Valley where it began parasiting the least Bell's Vireo. The vireo is a riparian scrub species whose habitat had been greatly reduced by human activities. By about 1970, the vireo was eliminated from its remaining habitat throughout the Central Valley (Goldwasser et al. 1980), and the subspecies was declared endangered.

The least Bell's vireo now occurs only locally in southern California coastal drainages where it is threatened by water development projects and cowbird parasitism. The cowbird has more recently invaded the Sierra Nevada and is probably increasing in response to habitat disturbance (Rothstein et al. 1980, Verner and Ritter 1983). The warbling vireo and other small songbirds may be locally threatened in areas of the Sierra where humans and livestock concentrate (Airola 1986).

Cumulative impacts to biological systems are becoming increasingly common and noticeable in California. Scientists and regulatory agencies have barely begun to grapple with the technical and political problems of how to identify, mitigate, and prevent cumulative impacts. These are likely to be among the most important and controversial issues relating to protection of natural diversity and the environment in coming years.

Underlying Causes

Specific impacts to communities or populations often result directly, indirectly, or cumulatively from an individual development project or resource management action. But the larger pattern of diminishing natural diversity in California has a more complex origin. Many different kinds of environmental impacts have been occurring at accelerating rates for more than a century. Ultimately, this loss results from increasing demands by California's growing population (Figure 7). Habitat loss and the disruption of species breeding and migration patterns have resulted from the cumulative effects of many independent activities carried out in various locations and at different times.

Global Threats

In addition to local and regional impacts, California's natural diversity could be altered through potential global impacts. Impacts of threats are not precisely understood, but potential impacts are enormous. Changes in the chemical composition of the earth's atmosphere, for example, could threaten plant and animal species, including humans. Reduction in atmospheric ozone could result in overexposure to solar ultraviolet radiation. Increases in carbon dioxide from burning of fossil fuels could increase global air temperatures (i.e., the "greenhouse effect") and cause substantial biological and economic disruption (Kellogg and Schware 1981).

Loss of the world's tropical forests may affect California species, in addition to threatening the enormous wealth of tropical species. Many migratory species that breed in California winter in Latin America and may be reduced by future tropical forest deforestation (Keast and Morton 1980). Removal of wet forests may also affect global climate (World Resources Institute 1985, Davidson 1985).

Nuclear war also poses a global threat to many species. Many species could be immediately and completely eliminated by nuclear blasts. Subsequently, smoke and ash from burning forests and debris could create a "nuclear winter," during which cold, darkness, and disease might exterminate millions more species (Middleton 1982, Peterson 1986). Threats from potential global impacts must be addressed through a combination of international diplomacy, further research, and legislative and administrative action.

Sharing the Responsibility

The purpose of this chapter is not to parcel out specific blame for past, present, and future losses of natural diversity in California, but to show that a major problem exists and that virtually all Californians contribute to the problem. The causes of habitat loss are varied, and cumulative impacts are pervasive and complex; thus no single industry, community, economic sector, or political party can be assigned all, or even most of the blame. Every individual, no matter how ecologically attuned his or her intentions and lifestyle may be, ultimately contributes to the loss of biological diversity.

Responsibility for losses of natural diversity must be shared by all Californians, because we all place demands on the state's natural resources. This shared responsibility also obligates us to ensure that additional losses of natural diversity are minimized through land protection, wise resource management, and careful land use planning.

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Chapter 4

PROTECTING CALIFORNIA'S NATURAL DIVERSITY

Natural diversity can be protected in two general ways: through laws and regulations, and through ownership or management of land. Neither approach can succeed without the support of the other. The following sections describe and assess the effectiveness of protection available to natural diversity in California.

Protection Through Laws and Regulations

Overview of Federal Laws and Programs

Federal laws preserve habitat diversity in three ways. Some permit or require the acquisition and management of important habitats. Others, such as the Migratory Bird Treaty Act, protect particular species from destruction. Finally, protection of habitat diversity is a benefit of laws requiring consideration of general environmental quality goals (e.g., the National Environmental Policy Act [NEPA]). Decisions about the level of support, implementation, and enforcement for federal laws are made at the national level. The federal government also participates in international efforts to preserve habitat diversity.

Federal Law. Federal authority to preserve wildlife species and their habitat stems from three constitutional sources. Under the Property Clause of the U. S. Constitution (Article IV), the federal government has power to regulate and protect species and habitats on federal land. Under the Supremacy Clause (Article VI), federal law governs if state statutes are in conflict over wildlife resource management issues. The Treaty Power of the Supremacy Clause gives the federal executive exclusive authority to enter into international treaties and conventions. Under the Commerce Clause (Article I), the federal government has broad powers pertaining to wildlife where interstate commerce may be affected.

The major federal laws that protect biological diversity and their resulting programs in California are briefly described in Appendix 3.

Agency Regulations. Federal agencies, particularly the U. S. Forest Service (USFS), Bureau of Land Management (BLM), U. S. Fish and Wildlife Service (USFWS), and National Park

Service (NPS) have developed internal regulations that manage habitat for diversity or for other purposes consistent with maintenance of habitat diversity. The regulations identify many land classes that are designated primarily for protection of resources in their natural state. Research Natural Areas (RNA) are representative ecosystem communities, habitats, and phenomena that are preserved to serve as gene pools for genetic diversity and managed for nonmanipulative research. Special Interest Areas are areas with significant habitat, ecological phenomena, or other botanical or zoological features managed to encourage nondestructive public use. Outstanding Natural Areas are managed for recreation consistent with preservation of outstanding natural values of the areas. These designations are usually subject to substantial local discretion and are limited to lands under federal agency jurisdication (Cochrane 1986).

International Programs and Treaties. Several international treaties protect species and their habitats. The early treaties, beginning in 1916, protected specific species (notably migratory birds) from hunting except in designated seasons and under prescribed methods. In 1942, the U. S. entered the Convention on Nature Protection and Wildlife Preservation in the Western Hemisphere where a stated goal was to conserve specified habitat types.

The U. S. joined in several conservation treaties in the 1970s. The most significant, for habitat diversity purposes, was the Convention Concerning the Protection of the World Cultural and Natural Heritage proposed by the U. S. and signed in 1973. This convention established a network of protected areas and a mechanism to identify and preserve areas of outstanding cultural and natural importance including national parks, national reserves, natural monuments, and wilderness areas.

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), signed by the U. S. in 1975, is another important treaty indirectly affecting habitat preservation. CITES regulates the import and export of protected species.

The 1971 Convention on Wetlands of International Importance Especially as Waterfowl Habitat (Ramsar Convention) established a network of wetlands of international importance and provides legally enforceable protection for specified wetlands. This treaty was signed by the U. S. in 1987. Several other treaties, such the International Convention for the Regulation of Whaling, are as signed by the U. S. to protect specific wildlife species.

The 1982 Law of the Sea Convention requires that sound principles be used to preserve and protect the marine environment. This treaty remains unsigned by the U. S.

Most international treaties pertaining to conservation are what has been termed "soft law" (Office of Technology Assessment

1986). They state broad policy goals without providing mechanisms for enforcement. As a result, their provisions are generally unenforceable except through formal or informal sanctions.

State Laws and Programs

Many 19th century legal decisions concerning conservation law were based on the concept that states had ownership of the wildlife within their boundaries. More recently, the state ownership concept has been eroded with the passage of federal laws governing wildlife (Bean 1983). State laws provide for habitat acquisition, species protection, and incidental protection of species and habitats. State laws and programs also encourage and cooperate with local and private interests in the preservation of habitat.

A potential basis for more state influence over habitat diversity has arisen in the past two decades via the Public Trust Doctrine. This doctrine holds that certain natural resources are to be held in trust for the public good rather than for private exploitation. Traditionally, this doctrine has been used to maintain public access to seacoasts and tidelands. Other interests recently included within the public trust are instream flows for streams, rivers, and lakes (Dunning 1981).

California Legislation. California's legal framework for resource conservation, like the federal framework, focused initially on game species. Recent California statutes have been enacted with the primary goal of preserving habitat diversity. The major state laws that provide protection to biological diversity in California are listed in Appendix 3.

Management Regulations. Habitat diversity is protected by a variety of state agency regulations. Policies for the DFG are established by the Fish and Game Commission. The Commission has the authority to acquire land as Ecological Reserves to protect threatened and endangered species and specialized habitat types. The Commission may acquire land for Ecological Reserves only from willing sellers.

Policies of the Department of Parks and Recreation (DPR) also contribute to the maintenance of habitat diversity (Barry 1987). One mission of the State Park System is to preserve California's natural heritage, including the acquisition and management of outstanding complete ecological units.

Three State Park System land unit classifications preserve habitat diversity. State Reserves preserve native ecological associations and prohibit the disturbance or removal of resources. Natural Preserves are distinct areas of outstanding natural or scientific significance within state park units. Preserves protect threatened or endangered species and their habitats as well as representative examples of California's plant and animal communities. The third classification, State Wilderness, was described previously under the California Wilderness Act.

The University of California also manages a Natural Reserve System. This system includes habitat diversity as a criteria for selecting appropriate units. Each campus is responsible for it's own Reserves. Managers have broad discretion and may permit habitat manipulation for scientific purposes (Cochrane 1986).

Effectiveness of Current Legal Protections

Many state and federal laws, and their implementing regulations, provide protection for natural diversity in California (Appendix 3). How effective are these laws? What additional protection may be needed? We address these questions in a general way for both state and federal laws.

Federal Laws. Several federal laws provide important protection for threatened and endangered species and habitats, and for sustainable management of public lands. Unfortunately, other laws, such as those providing subsidies for land reclamation, or authorizing water projects and freeway construction, have caused large losses of natural habitats.

The federal Endangered Species Act provides strong protection of federally listed threatened and endangered species and their habitats throughout the nation. On federal lands the law requires that management be conducted not simply to protect the existing populations of species, but to actively encourage the recovery of endangered species' populations.

The act prohibits "taking" (i.e., killing, injuring, etc.) a wildlife species. It also prohibits habitat destruction that would detrimentally affect a species on both public and private lands. Amendments to the Act in 1982 allow incidental taking of protected species on private land if a habitat conservation plan (HCP) is developed and approved by USFWS to minimize and mitigate impacts in the species (Section 10[a]). An HCP describes compensating actions that must be accomplished on private lands when a proposed project may detrimentally affect populations or habitat of an endangered species. The Section 10(a) process is a powerful tool to protect species' habitats on private lands, especially when applied in a coordinated way to large land areas.

Other federal laws provide substantial protection for various designated areas. These laws include the specific acts establishing wilderness areas, national wildlife refuges, and wild and scenic rivers. Laws governing land management and planning procedures also include provisions that ensure that species and habitat values are considered and protected; these acts include NEPA, the Fish and Wildlife Coordination Act, the Clean Water Act, the National Forest Management Act, and the Federal Land Policy Management Act.

Federal protection is limited in many ways. For the most part, federal laws apply only to actions that occur on federal lands, to federally funded projects on private lands, or to projects that require federal permits. A major example of effective protection of private lands under the permitting process is The Clean Water Act's Section 404 requirement for permits from the U. S. Army Corps of Engineers (COE) for all projects that affect wetlands. Many wetland losses on private lands have been avoided or mitigated through compensation as a result of this law.

State Laws. Compared to most states, California has a well-developed program for protecting environmental resources. In many ways, however, California laws are insufficient to prevent losses of important biological resources.

Major California laws that protect species and habitats include the state Endangered Species Act, the Wildlife Conservation Law, and the California Environmental Quality Act (CEQA). The state Endangered Species Act provides important protections for endangered species and their habitats, but the act limits habitat protection to state lands or to projects in which a state agency is the principal sponsor (Cummings 1987). The Wildlife Conservation Law established the Wildlife Conservation Board (WCB), which purchases important wildlife habitats for protection and public use. WCB funds come from a variety of sources including bond acts, hunter's duck stamps, agency appropriations, and private mitigation funds. Many outstanding biological areas have been protected through WCB purchases.

CEQA requires environmental analyses for all state and private projects that may affect the environment; all significant impacts (even to species not listed as threatened or endangered) must be identified and mitigated, or overriding concerns explained. CEQA's requirements for analysis, disclosure, and mitigation have substantially reduced the impacts of recent development in California.

Inadequacies in Current Legal Protection. Despite their considerable benefits, current legal protections have not adequately safeguarded California's natural heritage for several reasons. First, some laws and programs are not being fully implemented by public agencies due to inadequate funding (Nicola 1987). One important example is the lack of funding provided to state and federal agencies to evaluate candidate species for threatened and endangered status. Many species (especially plants and invertebrates) that would likely qualify for legal protection have not been designated because their status has not been scientifically or legally documented sufficiently to meet requirements for listing. Similarly, many designated species receive little or no active management or habitat acquisition to assure recovery, due to lack of funds. Enforcement of provisions against taking species and their habitats are also limited by funding.

A second major inadequacy in the legal system pertains to protecting critical biological resources from private actions on private lands. Although designated wildlife species are protected from taking on private lands, the state law exempts plants from the taking provision by requiring only that landowners provide 10 days notice to DFG to permit salvage (Cummings 1987). In addition, many other unlisted species and rare habitats in dire condition receive little or no protection on private lands from actions that do not require preparation of environmental impact reports (EIR) and Environmental Impact Statements (EIS) under CEQA and NEPA. These actions include agricultural conversion, forest management, and livestock grazing.

A third deficiency is the lack of state protection (beyond CEQA requirements) for critically endangered habitats that do not necessarily support listed plant species (Holland 1987). Continued destruction of uncommon, unprotected species and communities may lead eventually to listing of new species or possibly to complete extirpation before listing occurs. Waiting to initiate protection until a species is listed is dangerous for the species and counterproductive because it forecloses easier and cheaper protection options.

Protection through Ownership and Management

Introduction: Patterns of Land Ownership in California

The historical conditions that created the existing patterns of public and private land ownership in California have had a major influence on the present condition and protection of natural diversity in the state. This is largely because land has been used more intensively on private lands; in addition, laws regulating the protection and management of native species and habitats are stronger on state and federally owned lands than on private lands.

Spanish and Mexican land grants, such as the large ranchos of coastal southern and central California, are the oldest legally recognized private ownerships in California. Later, during the gold rush, private land claims were established prior to and during the short-lived California Republic. These were honored by the federal government when statehood was conferred in 1850 (Dasmann 1966).

All unclaimed lands in California were ceded to the federal government as a condition of entering the Union, but many federal laws were subsequently passed to encourage the disposal of federal lands to private ownership (Hibbard 1924). As a result, much of the land that could be cultivated or irrigated was transferred to private ownership. Large amounts of productive foothill rangeland and forest land were also transferred. Reclamation acts, which granted diked, drained, or filled wetlands to the state, resulted in the formation of many reclamation districts and the destruction of millions of acres of coastal and interior marshlands.

By the early 1900s, lands in the public domain consisted largely of lands that lacked water or were unproductive for crops or forage. About this time, California's growing population began expressing concerns about the effects of private land uses. In response, National Forests were established during the early 1900s to ensure a continuous supply of timber and to protect watersheds. California's early National Parks were designated mostly from National Forest lands to protect outstanding scenic, recreational, and biological areas. The forests and parks consisted mainly of middle and high elevation areas. Remaining federal lands managed by the BLM included the relatively unproductive Mojave and Colorado deserts, the woodlands and shrublands of the Great Basin, and a scattering of dry grasslands and chaparral of the Sierra Nevada and Coast Range foothills.

The historical pattern of land ownership affects the current condition of natural diversity in California. Upland and desert habitats on public lands are reasonably well protected under federal multiple use policies. In contrast, natural habitats on many fertile and accessible lowland private lands have been widely eliminated through intensive land uses. On the whole, natural diversity on private lands has suffered because of the absence of management for multiple use, sustainable yield, and protection of natural biological diversity.

There are, of course, many important exceptions to these generalizations. On public lands, there are many instances of biological resource degradation through consumptive land use. On private lands, there are many places where biological diversity has been protected by design or through benign neglect.

Although many private lands have recently been acquired for parks, preserves, and wildlife areas, many more areas that support endangered plants, animals, or communities remain unprotected. More than 3,300 (almost 43 percent) of all documented occurrences of California's most threatened plants, animals, and natural communities are on private land (Natural Diversity Data Base 1987). These sites are among the highest priorities for acquisition by both public and private organizations working for the protection of biological diversity in California.

Extent of Protected Areas in California

Overview. Public lands in California encompass nearly 45.9 million acres, or about 45 percent of the state (California Department of Finance 1986) (Figure 8). These include about 11.5 million acres (25 percent of all public lands) managed largely for the preservation of outstanding natural landscapes or significant biological resources (Table 8). About 88 percent of these lands are in federal ownership, primarily as national parks and wilderness areas. Another 12 percent are administered by DPR, DFG, and the University of California.

Private lands account for 55.7 million acres, or about 55 percent of the state. Only 130,500 acres (0.2 percent) of all private lands are managed primarily for protection of natural diversity (Table 8). The Nature Conservancy (TNC), a national nonprofit organization dedicated to the preservation of natural diversity, is the largest private owner of protected lands. The amount of private protected lands is much smaller than the amount in public ownership, but the private lands are disproportionately important. Many species and communities with little or no protection on public lands have been protected specifically through purchase by private groups. Many of these preserves are located in areas with little land in public ownership or little opportunity for protective management on public lands.

In addition to the public lands designated primarily for protection, many other public lands in California support threatened species or natural communities. The National Forests, for example, include 16.6 million acres of lands managed for multiple uses, including timber production, livestock grazing, and production of other commodities. Within designated multiple use lands, many local areas are managed primarily for endangered, threatened, or sensitive species, or for general biological values (Smith 1987). Specific land uses for multiple use lands are currently being designated in National Forest Land Management Plans.

BLM manages over 17.1 million acres of land, some of which is given priority for wildlife and vegetation protection and enhancement. Nearly 2.8 million acres are managed by the U. S. Army, Navy, and Air Force (California Department of Finance 1986). Although grazing, military training exercises, and other disruptive uses prevail over many of these lands, legally designated sensitive biological resources are protected. Some active management programs have been implemented on military lands to protect and enhance biological values (Ramsey 1986).

Protection of Habitats. California's habitats are not evenly represented in protected areas. Because of historical factors previously described, the largest protected areas are in rugged mountains or other areas not suited for agriculture. As shown in Table 9, large areas of alpine, subalpine, and mid-elevation conifer are well protected. Many of these types

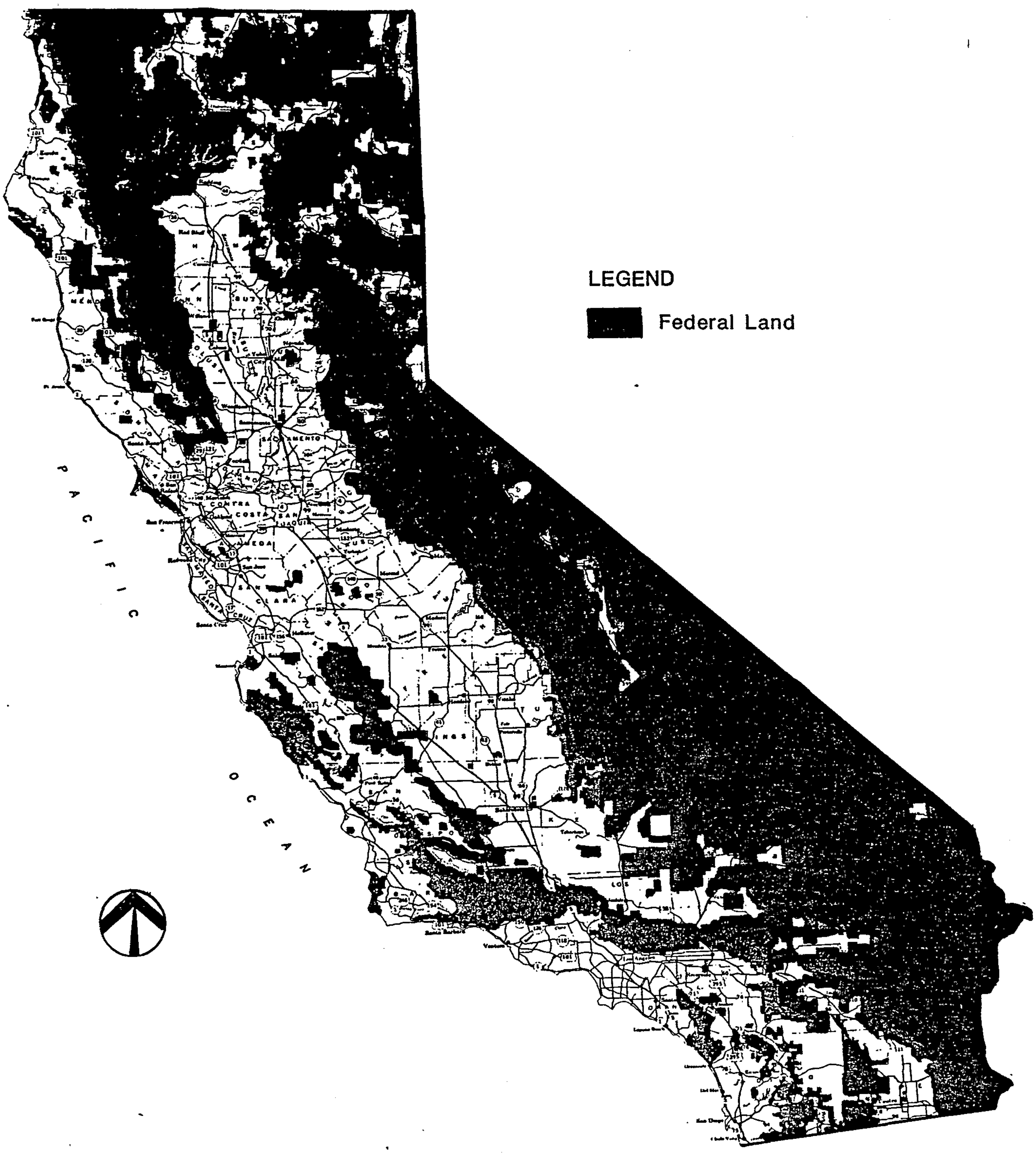

FIGURE 8. DISTRIBUTION OF FEDERAL LANDS IN CALIFORNIA

Source: Bureau of land Management (unpublished)

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occur in national parks, national monuments, wilderness areas, and state parks. Most other major habitats have 8-14 percent of their acreages within protected lands (Table 9). The montane hardwood, valley foothill hardwood, grassland, and lowland riparian types are the most poorly represented in reserves.

Many small sites of biological importance, which were not included in the acreages in Table 9, are managed as RNAs, State Parks and Reserves, Areas of Critical Environmental Concern (ACEC), and Ecological Reserves. These areas contain some of our best-protected representatives of chaparral and scrub communities, desert wetlands, and uncommon forest types. TNC's Preserves and other sites in private ownership comprise a small portion of well-protected land in California, but contain some of the best representatives of lowland habitats, such as vernal pools, grasslands, oak woodlands, and riparian forests.

Selection of Protected Areas

Areas are selected, designated, and administered for protection of natural diversity by numerous federal, state, and private agencies. The agencies and types of managed areas most important for the protection of natural diversity in California are listed in Table 8. Several other agencies and organizations recognize significant natural areas, but lack the authority or resources to provide comprehensive protection. Natural diversity in California has benefited when different agencies have worked together for resource protection. It also has suffered in many cases, however, from inadequate coordination. As a result, acquisition efforts have been duplicated in some areas, while other important sites have been overlooked (Hoshovsky 1987).

The location and configuration of preserves in California have been influenced as much or more by economic, political, and historical factors, and other resource management concerns than by biological considerations. For example, many national parks were designated primarily for their scenic and recreational values. Despite this tendency, many fine areas containing important elements of natural diversity have been protected. But future site protection must rely increasingly upon careful planning and interagency coordination to assure success. Without such efforts, many of California's rarest and most sensitive species and communities could face severe reduction or complete extinction.

A major need is to improve the process for determining agency priorities for land protection. This requires good information on the distribution and ownership of lands containing rare species and communities. All sites containing rare biological elements should be evaluated and given priorities for protection of natural diversity. Rankings should be designed to maintain species and habitat diversity statewide by preserving rare or unique species and fragile environments, and by protecting high quality examples of all ecosystems throughout their ranges (Margules and Usher 1981). Ecological factors such as migration routes, symbiotic relationships, land uses beyond the site, and many others must be considered fully in determining the size, shape, location, and management of protected areas (Wilcox et al. 1986, Jensen 1987).

The current site selection process is improving greatly through the work of the Lands and Natural Areas Project (LNAP), part of the Nongame-Heritage Program of DFG. LNAP is developing a computerized inventory of California's significant natural areas. Sites identified in this inventory include: 1) occurrences of extremely rare species or natural communities; 2) locations supporting several rare, though not necessarily extremely rare, species; 3) excellent examples of representative communities; and 4) areas of high biological diversity. This inventory is continually updated, incorporating information from the NDDB, previous natural areas inventories, and knowledgeable biologists throughout California.

When fully developed, LNAP's inventory will provide conservationists with a valuable tool for assigning protection priorities to natural areas. LNAP's other responsibilities are to ensure the recognition of significant natural areas by public and private organizations, to encourage long-term protective management of these areas, and to provide coordinating services for organizations interested in protecting natural areas (Hoshovsky 1987).

An important step toward improved cooperation between public agencies was the establishment in 1986 of the Interagency Natural Areas Coordinating Committee. The committee includes representatives of DFG, DPR, USFWS, BLM, NPS, TNC, and the University of California Natural Reserves System. It provides a forum for agencies to update each other about natural areas protection activities and to discuss cooperative efforts (Hoshovsky 1987).

Management of Existing Protected Areas

Management objectives for California's existing protected areas are highly varied. Few areas are managed exclusively for the preservation of natural diversity. Most are managed in part for other uses that may sometimes conflict with the maintenance or enhancement of natural diversity. Education, watershed protection, and passive forms of recreation are usually compatible with this goal, but grazing, timber management, intensive motorized recreation, mineral extraction, and management for certain species (e.g., nonnative game species) can significantly compromise diversity values.

Many of the lands in NWRs and State Wildlife Areas in the Central Valley are managed intensively by growing agricultural or wetland food crops for migratory waterfowl. This practice reduces native plants, but is extremely important in maintaining populations of waterfowl, raptors, and many other wildlife species that have been reduced or eliminated in their natural habitats. These populations contribute significantly to regional and statewide wildlife diversity.

Other management compromises result from the landowner's limited financial capacity to provide onsite protection. Rangers, stewards, maintenance crews, and facilities such as fences, roads, cattleguards, and erosion control structures, are needed for effective protective management, but are also costly.

Some significant resources in protected areas may be affected by outside influences. For example, over 90 percent of the Jeffrey pines in portions of Sequoia and Kings Canyon National Parks have been injured by ozone or other air pollutants produced in the San Joaquin Valley and South Coast Air Basin (Bennett 1986). Waterfowl at Kesterson NWR have been poisoned by selenium in agricultural drainage water originating off of the refuge (U. S. Bureau of Reclamation 1986). Portions of tidal marshlands at Elkhorn Slough Ecological Reserve have been buried under soil eroded from adjacent farm lands (Dickert and Tuttle 1985). Such problems are becoming more common as land uses intensify in areas upwind, upstream, or adjacent to existing protected areas.

Some imperiled migratory species or species that have extremely large home ranges cannot be fully protected in preserves. Single preserves can protect only a portion of the population and for only part of the year. The bank swallow, currently under study for listing as threatened in California, winters south to Argentina. The threatened Swainson's hawk winters in Central and South America. The endangered Aleutian Canada geese summer in the Aleutian Islands. In the wild, California condors were not migratory, but they foraged over thousands of square miles. At best, only critical sections of their habitat can be included in preserves. One recent study suggests that even California's largest national parks are too small to have maintained populations of certain mammals with low population densities and large home ranges (Newmark 1987).

Some very small preserves adequately protect certain organisms and habitats. Small preserves effectively protect some plant species with small populations in specific habitats. Examples are the Tiburon mariposa-lily and Tiburon jewel-flower at the Ring Mountain Preserve, and the many plants endemic to "pebble plains" at the Baldwin Lake Preserve, both properties of TNC.

Adequacy of Existing Site Protection in California

Although many important biological resources are protected in California, acquisition and protective management is needed for many sites that contain, in the words of TNC, "the last of the least and the best of the rest" of California's unique natural diversity. A few examples will illustrate the variety of needs.

Some of the highest protection priorities are the vernal pools occurring on basalt flows and volcanic mud flows in the Sierra Nevada foothills and Modoc Plateau, the mesquite woodlands of the lower Colorado River, and the Ione chaparral of western Amador County (Holland pers. comm., Holland 1986). Each of these communities provides habitat for several threatened species and has been reduced to only a few degraded occurrences. Each occurs mainly on unprotected private lands and is threatened by development, woodcutting, mining, competition from nonnative species, or other factors. Communities considered by NDDB to be rare enough to maintain site inventories are listed in Appendix 4.

Many rare or endangered species and communities in California occur partly or entirely on private lands where they are not protected. Of nearly 7,800 rare species and community occurrences for which ownership is known, over 3,300, (43 percent) are on private lands (Natural Diversity Data Base 1987). Future protective efforts must therefore be directed toward private lands, including acquisition of new protection areas, management to ensure protection, and notification and education of landowners.

Most (about 57 percent) of the other known sites supporting of California's rare or endangered species and communities are on public lands administered by city, county, state, or federal agencies (Natural Diversity Data Base 1987). Many of these sites receive little or no direct protective management to ensure long-term survival of rare diversity elements. Improving protection of these areas requires increasing the awareness of land managers, and providing funding and staffing for management and monitoring.

Opportunities for Improved Site Protection

Many opportunities exist for improving protection of rare species and habitats. Major actions include acquisition of private lands and improvement of management and coordination on public lands. Urgent action is needed to take advantage of these opportunities before they are lost.

Excellent programs for land protection already exist in the state, but they are inadequately funded and staffed to protect important priority sites already identified by NDDB, CNPS, and other governmental agencies and private groups. Modest funding acres of marsh and riparian habitats were converted to agriculture.

Although levee construction protected some areas from flooding, it did not eliminate the huge accumulations of water in the valley each winter and spring. Construction of dams on tributary rivers, however, permitted storage of peak runoff and regulated winter and spring flows. This further reduced flooding and encouraged additional levee construction and land conversion.

Current Status of Valley Wetlands

By 1978, wetlands in the Central Valley had shrunk to only about 4 percent of their original extent (U. S. Fish and Wildlife Service 1978), and they have declined since then.

The Central Valley hosts over 50 percent of the total wintering waterfowl in the Pacific flyway (U. S. Fish and Wildlife Service 1978) and high proportions of some waterfowl species (Table 10). Populations of wintering waterfowl averaged 7.4 million from 1976 to 1985, a figure greatly below historical levels. Populations naturally fluctuate annually due to many factors, including water conditions on the northern breeding grounds and wintering habitat quality and quantity. Populations as a whole are on a downward trend (Connelly pers. comm.); in 1987, wintering waterfowl numbers dropped to 2.5 million, the lowest level since surveys were initiated in 1955 (Bartonek pers. comm.). As remaining birds crowd onto fewer acres of habitat, disease outbreaks are becoming more frequent. Natural wetland foods are declining with wetland losses and agricultural waste foods have also declined as commercial harvesting efficiency has increased (Miller 1987).

Almost 80 percent of the remaining Central Valley wetlands occur on private duck clubs; many of these are being converted to agriculture due to increased operating costs (Rempel 1974, U. S. Fish and Wildlife Service 1978, Jacobsen and Maier pers. comms.). Even state and federal wildlife refuges in the valley face serious threats from lack of adequate water supplies and contamination of available water with harmful natural elements (e.g., selenium, boron), salts, and pesticides (U. S. Fish and Wildlife Service 1978, U. S. Bureau of Reclamation 1986, Ohlendorff et al. 1986, SVWHMC no date).

The declines in waterfowl and other wetland wildlife populations not only represent recreational losses to those who hunt and view these species, but also pose a long-term population threat to many species or subspecies that winter mainly or only in California. These include species such as the Ross' Goose, and subspecies such as the Pacific white-fronted goose, tule white-fronted goose, cackling Canada goose, and Aleutian Canada

Table 10. Pacific Flyway Waterfowl Species and Subspecies That are Highly Dependent on Wetlands in California's Central Valley

Species/Subspecies	Central Valley Wintering Population	Percent of Pacific Flyway Population Wintering in Central Valley
Snow and Ross' goose[a]	416,000	93
White-fronted goose	65,000	93
Cackling Canada goose	51,600	89
Whistling swan	44,500	86
Cinnamon teal[b]	1,900	86
Northern shoveller	572,000	80
Wood duck[c]	3,700	78
Northern pintail	2,980,000	75
American wigeon	472,000	58
Gadwall	16,600	57
Green-winged teal	158,000	47
Canvasback	34,800	44
Ring-necked duck	1,300	32
Mallard	415,000	28

[a] These species were not recorded separately on surveys.

[b] Most cinnamon teal move south of the surveyed area into Central and South America.

[c] Numbers greatly underestimated because species generally occurs in wooded habitats where visibility is obstructed during surveys.

Source: U. S. Fish and Wildlife Service 1978.

goose (Bellrose 1976, U. S. Fish and Wildlife Service 1978, SVWHMC no date).

Wetlands of the Kern-Tulare Basin

The Kern-Tulare Basin is the drainage basin for the Kings, Kern, Tulare, and Kaweah Rivers in the southern San Joaquin Valley. The basin once supported the largest single block of wetland habitat in California in a series of shallow permanent and seasonally flooded lakebeds (U. S. Fish and Wildlife Service 1978). Tulare Lake once was the largest lake west of the Mississippi (Griggs 1983). Today the marshlands are nearly gone, converted to farmlands that now make the area one of the most productive agricultural areas in the U. S. (Preston 1981).

Historical Conditions. The Tulare Basin once contained four major water bodies: Tulare, Goose, Kern, and Buena Vista Lakes. Together, these lakes covered 1,200 square miles and contained 2,100 miles of shoreline (Werschkull et al. 1984). For comparison, Lake Tahoe occupies only 193 square miles. In wet years, the four lakes overflowed, creating one lake nearly 80 miles long. Occasionally, the basin filled and spilled into the San Joaquin Valley (Katibah 1984). The basin also stored abundant groundwater that maintained many artesian wells where fresh water bubbled to the surface.

The four lakebeds supported vast stands of emergent marsh plants. When explorer Jedediah Smith entered the Tulare Basin in 1825, he reported that no part of the U. S. was so densely populated by Indians (Cone 1911 in Preston 1981). The Indians harvested abundant fish, shellfish, waterfowl, and aquatic plants from marshlands, as well as game and plants from uplands.

Early explorer Kit Carson reported that wildlife, including tule elk, pronghorn, mule deer, grizzly and black bears, mountain lions, beavers, river otters, and feral horses and cattle, were abundant in the basin (Carson 1852 in Werschkull et al. 1984). John C. Fremont reported that he "travelled among multitudinous herds of elk, antelope, and wild horses" (Nevins and Morgan 1964). John James Audubon, while in the area, noted that "we were in the chosen county of the antelope," (Audubon and Bachman 1851 in Werschkull et al. 1984).

Swans, geese, and ducks were reported to "cover the plains and waters in countless myriads from October to April" (Carson 1852 in Werschkull et al. 1984). Many early accounts refer to the vast numbers of sandhill cranes that wintered in the basin and to breeding white pelicans.

The Tulare Basin lakes also supported a thriving trout fishery (Carson 1852 in Werschkull et al. 1984). In wet years, chinook salmon entered Tulare Lake and the Kings River (Moyle 1976). Pond turtles, which were reported in "unbelievable numbers," were seined commercially to provide meat "for hotels throughout the west coast." Numbers of freshwater clams were reported to be "more . . . than a person would believe" (Latta 1937 in Werschkull et al. 1984).

Resource Decline. Decline in the wetlands and other resources of the Tulare Basin began early. Major factors that led to the demise of natural habitats included surface and groundwater appropriation for irrigation, control of winter river flows through dam construction, and land reclamation (Preston 1981). Figure 9 shows the trends in irrigated acreage and size of Tulare Lake since the 1840s.

Irrigation was initiated in the 1850s by tapping tributary streams (Preston 1981). Water appropriation increased, reducing flows to the basin lakes. Large game herds declined rapidly early in this period due to market hunting, competition from domestic livestock, and agricultural conversion; by the mid-1860s, large game were rare (Hittell 1866 in Preston 1981).

Groundwater pumping began in the early 1900s and has accelerated. Dropping groundwater levels were noted in the 1920s and have continued (Department of Water Resources 1986). Most springs have ceased flowing. Groundwater overdraft caused land subsidence of 20 feet or more in some areas (Polland et al. 1975).

Full-scale reclamation of marshlands to increase agriculture began after 1905. Reclamation districts constructed levees to confine the remaining Tulare Lake waters to a smaller area and thereby permitted cultivation of reclaimed areas. By the 1940s, the remaining lake was confined to 36 square miles, only 3 percent of its original extent (Preston 1981). Dam construction in the 1960s on tributary streams reduced peak flows to the basin and permitted further conversion of marshlands formerly required for floodwater storage (Reisner 1986).

Current Status. Wetlands in the Tulare Basin now occupy 6,000 acres, less than 1 percent of their original extent (U. S. Fish and Wildlife Service 1978). Current wetland areas consist of the USFWS' Kern NWR, TNC's Creighton Ranch Preserve, private lands still used for storage of floodwater and agricultural drainwater, and a scattering of private duck hunting clubs. Many of the remaining marshlands once watered by stream overflows and springs now rely on groundwater pumping.

Many evaporation ponds that store and dispose of agricultural drainage water contain concentrations of selenium, boron, and pesticides (Boland 1986). These ponds have received less attention than the well-known Kesterson NWR, but initial studies suggest that conditions in some may be hazardous (Smith pers. comm.).

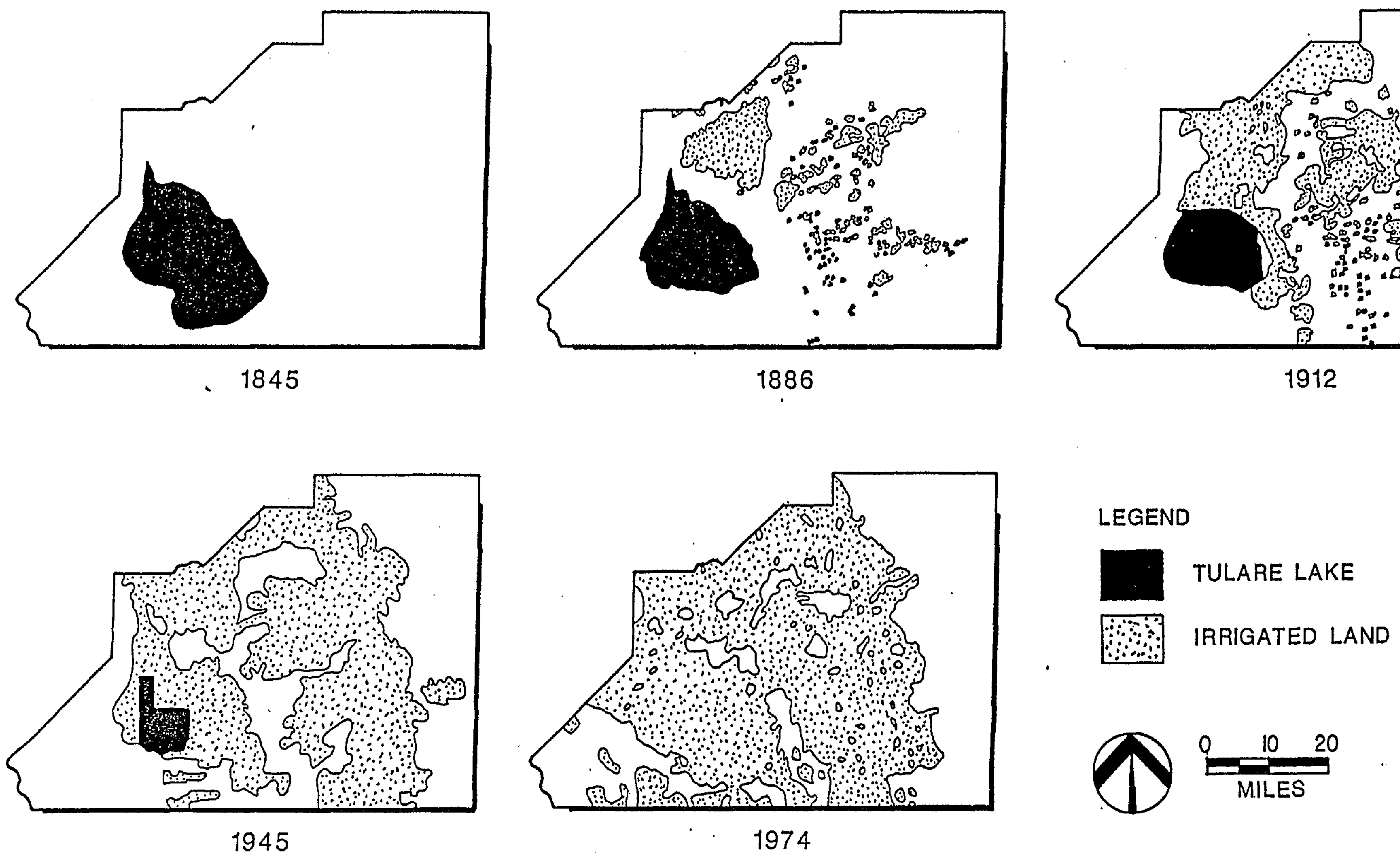

FIGURE 9. HISTORICAL CHANGES IN THE SIZE OF TULARE LAKE AND AMOUNTS OF IRRIGATED LAND WITHIN KINGS AND WESTERN TULARE COUNTIES, CALIFORNIA, 1845-1974

Source: Preston 1981

In 1978, the USFWS identified two areas within the Tulare Basin, Greenfield and Kern NWR-Wasco, as being among the highest priority for additional protection in the Central Valley. Since then, further losses have occurred in these areas because many duck club owners have been unable to afford the increasing energy costs of pumping water from the dropping aquifer (Jacobsen and Maier pers. comms.).

Other habitats that were once widespread in the Tulare Basin, such as riparian woodlands, shrublands, and grasslands, also have been reduced to small, scattered remnants. Many of these remaining areas support species designated as threatened or endangered (e.g., the San Joaquin kit fox and blunt-nosed leopard lizard) and species under consideration for designation (e.g., the Tipton kangaroo rat) (Werschkull et al. 1984).

The pronghorn, grizzly bear, mule deer, and mountain lion are gone from the valley floor. The vast tule elk population is reduced to a small remnant of 32 animals kept in a 953-acre enclosure on DPR's Tupman Reserve near Bakersfield. The bald eagle and white pelican no longer nest in the basin and are seen only occasionally (Werschkull et al. 1984). Wintering swans and geese now occur only irregularly in small numbers. The basin supports few breeding ducks, but wintering duck populations, although much reduced, are substantial (U. S. Fish and Wildlife Service 1978).

Protection and Enhancement Opportunities

Many actions are needed to protect the remaining Central Valley wetlands from current threats. The highest priority is to assure protection for existing wetlands. Creation of new wetlands through restoration of former wetland areas is also needed. The California Legislature has directed DFG to increase wetland acreage in the state by 50 percent by the year 2000 (California Department of Fish and Game 1983b).

Protection of existing wetlands may take a variety of forms. Full purchase can guarantee ownership control and appropriate management for wetland values. Purchase of easements also can prevent marsh destruction and help to offset operating costs and thereby maintain the economic viability of wetland uses. Easements that restrict other land uses can assure long-term protection and also reduce the land values, thereby reducing taxes.

Because of their need for a dependable water supply, wetlands are particularly susceptible to adjacent land uses that alter surface and groundwater availability. Many wetland areas do not have a secure annual source of water, but rather are dependent on year-by-year purchase of water from whatever sources are available. Similarly, many other areas depend on groundwater pumping and are subject to increasing pumping costs as groundwater is depleted by pumping for other uses. Guaranteed supplies of high quality water are needed to ensure that many public and private wetlands are productively managed (U. S. Fish and Wildlife Service 1978).

A major initiative using a creative mixture of protection strategies is needed to ensure that wetlands continue to be protected and managed to maintain the abundance and diversity of California's wetland wildlife.

Oak Woodlands

California supports 16 species of oaks (Munz and Keck 1972). Three species, blue oak, valley oak, and leather oak, occur only in California; many other species occur mainly within California (Griffin and Critchfield 1976, Tucker pers. comm.). California oaks grow in a variety of forms from compact shrubs to towering trees.

Oak woodlands provide many valuable resources. Historically, their acorns served as the staple food for many California Indian tribes. Oaks have been harvested for firewood since the early days of the Spanish influx. Today, their acorns still provide important forage for livestock, and they support a lumber and fuelwood industry.

Many current values are not easily quantified. Oaks provide important habitat for many wildlife species, including some threatened or endangered species. They contribute to California's beautiful and varied scenery and provide shade in parks and cities. They also enrich soils and protect watersheds and streams from erosion. Finally, and importantly, they include many unique species and comprise communities of ecological and scientific value.

Many of California's oak woodlands have declined substantially in both extent and quality. They are continuing to decline under pressures of agricultural conversion, cutting for fuelwood, livestock grazing, range forage improvement, urbanization, flood control, and fire suppression (Rossi 1980, Bolsinger in press).

Today, hardwood woodlands cover approximately 7.6 million acres of California (Bolsinger in press). Between 1943 and 1973, over 1 million acres of oak woodland were eliminated, mainly due to clearing for livestock forage improvement (Bolsinger in press). Since 1973, nearly 200,000 more acres have been lost; however, in this period residential and commercial development, along with road and freeway construction, were most responsible for the losses.

Recently, large scale firewood cutting has removed substantial amounts of foothill oak woodland in certain areas (Doak and Stewart 1986). Harvest levels exceed annual growth rates in the blue oak habitat type, and stands are declining (Bolsinger in press). Some amount of oak harvest has occurred within at least 773,000 acres, or 13 percent of the state's remaining oak woodlands (derived from Bolsinger in press).

Many of the remaining oak woodland communities are degraded. Livestock overgrazing prior to the mid-1900s eliminated many native understory grasses and herbs. Introduced Mediterranean annual grasses, which are more tolerant of grazing pressure, now dominate the understory in most oak woodlands (Griffin 1977, Heady 1977).

Lack of regeneration of young oaks may ultimately lead to loss of many oak stands. Regeneration appears to be insufficient to maintain existing stands in many oak woodland types (Muick and Bartolome 1986, Bolsinger in press). For example, recent studies showed only two percent of the state's blue oak stands were well stocked with seedlings and only 13 percent were moderately stocked (Bolsinger in press, in Mayer et al. 1986). Similar regeneration problems exist for valley oak and coast live oak woodlands (Mayer et al. 1986).

Causes of regeneration failure are not fully understood. Lack of regeneration has often been attributed to consumption of acorns and seedlings by livestock, big game, and rodents; competition with introduced annual grasses; and fire suppression (Griffin 1976, 1984; Rossi 1984; Holland in press; Oyler et al. in press; McClaren in press; and Sugihara and Reed in press). Only recently have detailed studies been initiated to evaluate the importance of these factors (Bartolome et al. in press, Mayer et al. 1986).

The loss of oak woodlands has important consequences for biological diversity and other human values. Many wildlife species depend on oaks for acorns, insect food, nest sites, and other uses (Verner 1984, Barrett 1984). As a result, decline in the extent of oak woodlands has reduced populations of many species. Declines also may reduce grassland forage production for livestock (Holland in press), long-term firewood production, and aesthetic values.

The Plight of Valley Oak Woodlands

The endemic valley oak was once prominent in the Central Valley and its surrounding foothills, and in coastal valleys. With its tall and wide canopy formed by twisting branches, the image of the valley oak is probably etched in the memories of most long-time Californians. Most recent immigrants to California, even those living where valley oaks were once most common, see only remnants of past stands.

The valley oak was a very common and widespread species in California. The beauty and abundance of pristine valley oak woodlands were noted often by early Californians. Journals and maps of early explorers and settlers indicated that riparian forests achieved their greatest width, 4-5 miles, in the lower Sacramento Valley. On the lesser streams and in the Sacramento-San Joaquin Delta, the forests formed a narrower belt, often up to 2 miles wide (Thompson 1977). One of Jepson's (1910) correspondents reported 400 square miles of valley oaks on alluvial soils of the Kaweah River.

Valley oaks were formerly common in areas with a high water table. They grew mainly on flat lands either above or away from the major river flows or in drainage bottoms of smaller tributaries which were kept moist by flooding at high flows and by subsurface irrigation.

Destruction of valley oaks began soon after the gold rush. Valley oaks were eliminated mainly by wood cutting, agricultural conversion, flood control projects, and urbanization (Rossi 1980). Firewood cutting removed many valley oak stands (Sudworth 1908 in Thompson 1977, Rossi 1980). Valley oak does not make good lumber (Wade pers. comm.), but 1-2 million board feet are harvested annually for pallets and a small amount of furniture lumber (Rossi 1980).

More than any other oak woodland type, the valley oak habitat has been impacted by agricultural conversion. As Jepson (1910) noted, early settlers knew that the presence of valley oaks was a sign of the richest soils and selected these areas for early cultivation. Although many areas occupied by valley oak were once unsuitable for agriculture due to frequent seasonal flooding, construction of artificial levees and flood control dams have reduced flooding and encouraged oak woodland conversion. As a result, valley oak woodlands, once miles wide, have been largely reduced to a scattering of giant, relict trees remaining on the immediate riverbanks and as shade trees around farmhouses and parks (Thompson 1977). In agricultural areas where scattered oaks have been preserved, oak regeneration is thwarted by frequent cultivation. In nonagricultural areas, valley oak regeneration is poor (Griffin 1973, 1980) and older trees that die are not being replaced.

Protection and Enhancement Needs

Protection of California's oak woodlands requires a combination of actions including land acquisition, research, education, and land use regulation. Generally, oak woodlands are not well represented in protective ownerships. Nearly 60 percent of all oak woodlands are privately owned and most are grazed by livestock. Certain habitat types are poorly represented in public ownership. For example, only 4,000 acres of the 29,000 acres of Engelmann oak within the state are publicly owned (Mayer et al. 1986). Similarly, only 39,000 acres (14 percent) of the remaining 274,000 acres of valley oak are on public lands. Many important oak habitats need additional protection through purchase by public agencies and private conservation organizations.

Although livestock grazing has altered oak woodlands to some extent through much of California, ranching also maintains the land in a more productive condition than many other land uses. Many recent losses in oak woodlands are attributable to economic hardships in the ranching community. As meat prices have declined, many ranchers have turned to firewood cutting or residential development for income.

Many issues regarding the status and management of oak woodlands require additional study (Muick and Bartolome in press). Major needs include: 1) a more detailed determination of oak status and decline; 2) the extent and causes of oak regeneration failure; 3) the importance of oak woodlands to wildlife; and 4) the development of new management techniques and land uses that will restore natural communities, maintain long-term land productivity, and assure private landowners of adequate economic return to prevent land conversion. Many research studies are under way, funded by CDF and University of California Extension Service.

Research findings must be applied on a large scale to maintain California oak woodlands. Debate exists over whether the application of improved management practices can be achieved through landowner education alone or whether regulation of management practices is needed by the State Board of Forestry or other government entities. The former approach is currently being implemented. If monitoring indicates that education is not effective, regulation may need to be instituted.

Vernal Pools

Introduction

California is renowned for its spectacular spring wildflower displays. They are an important part of the state's identity. They stimulate commerce and tourism, and contribute to a sense of place for millions of Californians. Amid the springtime greenery and flower fields of the Central Valley and a few other areas are thousands of shallow pools surrounded by bright concentric rings of white and yellow, and carpeted with vibrant hues of blue and green. These are the vernal pools, a marvelous and unique assemblage of natural communities that occur only in California and adjacent Mexico.

The most striking aspect of vernal pools, aside from the transient aspect that gives them their name, is their highly specialized flora and fauna, which includes many of our state's rarest and most endangered species. As many as 200 plant species may be restricted to vernal pools and similar seasonally moist habitats (Holland 1978). For example, all species of meadowfoam, including some very rare ones, are restricted to vernal pools. The seeds of meadowfoam contain a valuable oil with properties similar to those of sperm whale oil.

An entire tribe of grasses with remarkable morphological, chemical, and life history characteristics occurs only in the deepest vernal pools. Colusa grass and the seven species of Orcutt grass are all listed as endangered or rare under the California Endangered Species Act. Most of California's dozen different downingia species (delicately beautiful relatives of the familiar lobelias) are restricted to vernal pool habitats.

Vernal pools are most often appreciated, studied, and protected for their plants, but their fauna has also attracted scientific scrutiny. They support large populations of ostracods, clam shrimp, aquatic beetles, midge larvae, and other invertebrates that come and go in rapid succession as winter passes into spring. At least five kinds of fairy shrimp are endemic to California vernal pools (Eng pers. comm.) and could be endangered by loss of habitat. The California tiger salamander often uses vernal pools for breeding, and is a candidate for threatened or endangered status because of loss of habitat. Many species of vernal pool invertebrates have not yet been described. Studies indicate that many of these animals are actively evolving new species, and will continue to do so if we leave them sufficient habitat (Bowen et al. 1984, Belk 1984).

The remarkable biological diversity of vernal pools results from unique physical conditions. Most pools occur in level terrain that is underlain by an impervious layer of soil or rock, often a hardpan or claypan layer that has developed over many thousands of years. They occur in some of California's oldest and most interesting soils. These ancient soils are often very acidic, a condition that requires special adaptations by most plants. One of the most peculiar aspects of these old soils is the development of low mounds and ridges called "mima mounds." Mounded topography allows for the development of deeper pools, which are the preferred habitat of some of the rarest vernal pool plants.

The unique hydrological conditions of vernal pools result from California's Mediterranean climate, as well as from specific soil conditions. The rains of winter fill the pools with water, while the drought of late spring and summer evaporates the water and hardens the soil. Few habitats in California or elsewhere experience such extreme changes in conditions. California (together with northern Baja California) is the only place in the world where soil and climate combine to form the conditions found in vernal pools. The resulting biological diversity in California's vernal pools is unique in all the world (Thorne 1984, Stebbins 1976).

California's vernal pools are not all alike. At least seven major vernal pool types have been recognized (Holland 1986), and these can be subdivided further on the basis of substrate origin and soil chemistry. They occur on a variety of substrates, including active floodplains, former wetlands, basalt flows, sandstone outcrops, Pleistocene river and marine terraces, and former alluvial fans more ancient than the Sierra Nevada. Some are highly saline; many are slightly acidic; and others are highly acidic. They vary in size from puddles or "hogwallows" of a few square feet to lakes covering several acres. These physical differences are responsible for the extremely wide variation in biological communities found in vernal pools throughout the state (Stebbins 1976).

Most of California's vernal pools are found in the San Joaquin and Sacramento Valleys. They are relatively common in the grasslands that remain on the floodplains and terraces of these valleys. Vernal pools also occur in several smaller areas of level terrain in California west of the deserts. The northernmost occurrences of vernal pools are on the volcanic tablelands of the Modoc Plateau, in McArthur Valley in Shasta County, and on the coastal plains of Humboldt County. Vernal pools also occur along the coast at Point Reyes, near Santa Barbara, and on the coastal mesas of San Diego and Riverside Counties. Some of the most unusual vernal pools are small lakes in the North Coast Ranges south of Clear Lake (Holland and Jain 1977).

Current Status and Threats

Vernal pools of all types, and the species that depend upon them, are among the most threatened of all the state's natural diversity. Vernal pools have been destroyed over as much as 90 percent of their geographic range (Holland 1978, WESCO 1982). All seven Orcutt grasses and several other vernal pool plants are listed as endangered under the California Endangered Species Act. Many other species are imperiled, but are not yet officially listed. Without substantially increased efforts, many of these species could ultimately become extinct.

Today, vernal pools are still found throughout their historic range, but their numbers and density have greatly decreased. Vernal pools are now completely absent from portions of counties that once contained hundreds or even thousands of pools. Historically, most vernal pools were lost to agricultural expansion. Vernal pools are quickly destroyed when the land is plowed or leveled for crops or when the drainage pattern is altered. Recently, most losses resulted from urban expansion. Much of the land that is most in demand for expansion of Central Valley and the south coast communities is the best remaining vernal pool habitat.

Even where vernal pools are not being destroyed, many pools are being severely disturbed and degraded. Livestock often use vernal pools as watering holes, and in the process trample young plants and punch innumerable holes into the soft muds. Construction on nearby lands can introduce sediment to pools or interrupt water supplies. Offroad vehicles and unauthorized dumping of trash often damages or pollutes vernal pools. Construction of roads, canals, and other development corridors across lands with vernal pools can obstruct the dispersal of seeds, pollinating insects, and aquatic invertebrates from one vernal pool to another.

Vernal Pool Protection

Several ecological factors must be considered in planning for the protection of vernal pools. Habitat conditions range from wet to dry extremes during the life cycle of every vernal pool plant and animal. The chemical properties and temperature of soil and water change rapidly. Dry years regularly occur during which some species cannot reproduce at all. To accommodate these changeable conditions, vernal pool species must retain large amounts of genetic variability. When such variability is lost, species in this habitat may be unable to adapt and can go extinct. But genetic diversity tends to be dispersed among plants throughout groups of vernal pools, rather than concentrated within individual pools (Bowen et al. 1984). Species diversity is also dispersed, as individual pools contain only a portion of the species found in a local area (Holland and Jain 1977).

Protecting individual, isolated pools cannot assure the persistence of any vernal pool species. Effective vernal pool conservation requires that groups of vernal pools be protected, along with avenues for dispersal of organisms between them.

The peculiar hydrology of vernal pools depends on specialized soil conditions that have taken thousands, or even millions, of years to evolve. Topography and soil chemistry also influence the formation, character, and persistence of vernal pools. For these reasons, impacts to most vernal pools cannot be compensated by transplanting plants and animals from disturbed sites to artificial pools constructed in areas where none existed before. Only onsite preservation of existing vernal pools can provide for the long-term perpetuation of this uniquely Californian habitat.

So much variety exists within the habitat type we call "vernal pool," that an individual preserve, no matter how well designed, can protect only a small sample of the total diversity in the state. Adequate protection for our remaining vernal pools can only be provided by an extensive system of preserves that encompasses all of the variants of vernal pool habitats and communities.

Although important examples of vernal pool habitats have been protected in parks and preserves, only a tiny fraction of the original number of vernal pools and range of biological variation in vernal pools has been protected. Several distinctive types of vernal pools remain completely unprotected. Most endangered vernal pool species have little or no legal protection, and most of those that do still lack adequate protection on the ground.

Vernal Pools of San Diego County

The vernal pools of San Diego County occur on ancient marine terraces (Abbott 1984). They exemplify the pronounced regional differences between vernal pools. San Diego vernal pools share less than 15 percent of their species with most of the other vernal pools in the state (Holland and Jain 1981). The nine rarest plants in the San Diego pools occur nowhere else in California. Some of the commonest plants of the Sacramento Valley vernal pools are extremely rare in San Diego County (Bauder 1986).

San Diego County's vernal pools have suffered one of the most rapid losses of any natural habitat in California. Ninety percent of the estimated 37,000 vernal pools that once existed in San Diego County had been lost by 1978 (Beauchamp 1979). A more recent study (Bauder 1986) found that about 23 percent of the remaining pools had been destroyed between 1978 and 1986, and forecasted an additional 9 percent loss by 1990. Thus, less than 7 percent of all vernal pools that ever occurred in San Diego County will remain by the end of this decade. Locally, some losses could be much greater (Bauder 1986).

Numerous plant species are seriously affected by this habitat loss. San Diego mesa-mint and Otay mesa-mint are closely related species endemic to the San Diego area. Both have been reduced to only a few populations. Although they are legally protected endangered species, they continue to be threatened by development on private lands. The endangered California orcutt grass has suffered extensive losses in the San Diego area and now occurs locally only in a few pools on Otay Mesa. Prostrate spineflower shows a similar pattern of decline. Although not legally protected, it is a rare member of a group of similar species that is particularly diverse in the San Diego area. A rare and endangered moss (known only as <u>Geothallus tuberosus</u>) is restricted to elevated ground between some of the San Diego vernal pools (Norris pers. comm.).

The severity of habitat loss and species endangerment makes the San Diego vernal pools one of the natural communities most urgently in need of site protection in California. In 1980, the City of San Diego enacted a vernal pool preservation program in an effort to stem the tide of vernal pool destruction. Despite good intentions, hundreds of vernal pools have been lost to development pressures since its enactment. Mitigation funds collected to date would be enough to protect only a handful of pools, given the soaring cost of land in the area (Bauder 1986).

A more aggressive approach is needed to acquire land for vernal pool preservation in the San Diego area. Stronger enforcement is needed of existing legal protection including the state and federal Endangered Species Acts, CEQA, and NEPA. Implementation of the recovery plan for the San Diego mesa-mint would give hope to this species and the vernal pools in which it and many other species occur.

Serpentine Plant Communities

Introduction

California's complex geology and diverse soils are major contributors to the state's biological diversity. One of the most distinctive rock types in California is serpentinite. This greenish-gray, soapy-textured rock covers over 1,100 square miles in the Coast Ranges and Sierra Nevada foothills, and has been designated California's state rock. Weathering of serpentinite produces "serpentine" soils, which, because of their unusual chemistry, have played a special role in the diversification of the California flora.

Biological Significance

Most plants grow poorly in serpentine soils because the soils are severely deficient in calcium, nitrogen, and phosphorus, all of which are critically important plant nutrients. Most serpentine soils also contain high amounts of heavy metals which are toxic to many plants. Serpentine soils thus provide a habitat comparatively free of competition for any plant that can adapt to these conditions. This opportunity has led to the evolution of many serpentine-adapted species that are distinctly different from related plants that cannot live on serpentine.

In California, about 215 species, subspecies, and varieties of plants (about 3 percent of the entire native flora) are completely or largely restricted to serpentine soils (Kruckeberg 1984). More significantly, more than 8 percent of California's unique plants are restricted to a substrate covering less than 1 percent of the state. Serpentine endemics include a few trees, such as Sargent cypress and McNab cypress; several shrubs, such as leather oak; and many annual and perennial wildflowers. Thirteen species of jewelflower and eight species of dwarf flax are found only on California's serpentines. Eleven species restricted to these soils have been designated by the state or federal governments as threatened or endangered. Examples include the San Benito evening-primrose, McDonald's rock cress, and Tiburon mariposa-lily. Many more are rare, but have no legal protection.

Unlike plants, animals have evolved few distinct races or species in serpentine areas. No vertebrates, and only a few insects and other invertebrates are known. The Bay checkerspot butterfly in San Mateo County has adapted to plants and environmental conditions in a serpentine grassland that differs from surrounding nonserpentine habitats. Elsewhere, two species of Pierid butterfly have coevolved with several serpentine jewelflower species (Shapiro 1981). The faunas on serpentine have been studied far less than the floras. It is likely that many more unique, rare, and elusive invertebrates will be found in serpentine habitats.

Historical and Current Status

Today, many serpentine sites have been reduced in size or degraded. California's serpentine biota is imperiled as a result of many different kinds of disturbances throughout the history of California's settlement and growth.

California's serpentine soils are associated with important deposits of mercury, nickel, chromium, magnesium, asbestos, talc, and other minerals. Mining, which began in the 1840s, continues to be a major disturbance to serpentine communities. Woodcutting to fuel the furnaces used in mercury extraction also reduced the unique cypress forests of serpentine soils (Kruckeberg 1984).

Serpentine soils are among the state's poorest for production of livestock forage. Attempts to "improve" them to grow more nonnative grasses and forbs have generally failed. Such manipulation, together with grazing and trampling by livestock, have made the already difficult conditions even more unfavorable for many of California's unique serpentine plants (Kruckeberg 1984).

Serpentine communities have been consumed and fragmented by the expansion of cities, suburbs, highway systems, and public utilities, even though serpentine soils are very unstable and among the least suited for construction of all the state's soils. Serpentine plants and their habitats also have been disturbed in many areas by offroad vehicles and of recreational uses (Kruckeberg 1984).

Important Sites

Serpentine geological formations and their associated unique biota occur in the Coast Ranges from Santa Barbara County to southwestern Oregon, and in the Sierra Nevada foothills from Tulare to Plumas Counties (Kruckeberg 1984). Many serpentine

Chapter 6

RECOMMENDATIONS

Action should be taken to meet California's current and long-term needs for maintaining natural diversity. These needs are great and require immediate, extensive efforts to protect species and their habitats. The following recommendations should be implemented through a combined effort by the California Legislature, state and federal agencies, and private organizations to ensure protection of California's remaining natural diversity. We suggest this list as a starting point for protection efforts; we expect that these recommendations may elicit additional ideas for needed actions.

1. Increase Habitat Acquisition. State, federal, and private programs must be expanded and accelerated to identify and acquire unique, natural communities and habitats that support rare, threatened, and endangered species. Acquisition priorities should be determined through ongoing activities of the state LNAP. Permanent conservation easements rather than outright purchases should be used where possible to protect important sites at less expense.

2. Increase Environmental Review Capabilities of Agencies. Agency staffing is insufficient for adequate participation in the environmental review processes required under CEQA and NEPA. Projects that may potentially affect rare, threatened, and endangered species and important natural communities do not receive sufficient attention to assure that the existing legal protections are being implemented.

   Currently, agency staff efforts are concentrated on selected high priority projects. Increased staffing would allow participation in more projects and allow protection and mitigation measures to be better tailored to specific project conditions, habitats, and species. Increased staff time would also allow resource agency personnel to work more closely with the staffs of local planning agencies. This coordination could improve resource protection by improving mutual understanding of protection needs and opportunities.

3. Accelerate the Process for Listing State and Federal Endangered Species. Many species designated as state and federal candidates warrant listing as threatened or endangered species under the state and federal

acts, but remain unprotected. Increased scientific and administrative effort is needed to accelerate the scientific evaluation of species' statuses and to process the legal documentation required to list species under the acts. Currently, the USFWS is evaluating five species per year in California from a list of over 400 candidate species (Rado pers. comm.). Additional funding and staffing are needed to alleviate this backlog.

4. Expand the Scope of the California Endangered Species Act. The state endangered species act does not preclude the direct taking of state-listed threatened or endangered plant species by a landowner. The act protects the habitats of listed plants and animals only on state lands or within projects sponsored or approved by state agencies. As a result, listed plant species and habitats of both plants and animals on private lands are being legally eliminated (Cochrane 1987, Cummings 1987). Provisions should be added to the act to ensure protection of all listed species and their habitats as is the case with the federal act.

5. Protect Instream Water Flows. California's water laws should be amended to recognize protection of instream flows as a beneficial use of water that is competitive with existing appropriative uses. Such recognition could provide important protection to rare aquatic and riparian habitats and species. The state should establish this precedent through legislation (as have many other states) or in certain important areas through legal action under the Public Trust Doctrine.

6. Encourage Habitat Protection in Tax and Other Incentive Programs. Legislation is needed to provide tax benefits to individuals who protect rare habitats and species. For example, individuals who sacrifice economic gains to protect rare and endangered species and their habitats should not be taxed on the value of a higher economic use of the land. The Williamson Act allows landowners to enter into agreements to protect land in exchange for reduced taxation. Each county, however, determines which lands are enrolled in the program and many counties accept only agricultural land that is in full production. Incentives are needed to encourage all counties to enroll lands under Williamson Act for protection of important biological values. Alternately new legislation could be developed specifically for important species and habitats.

7. Develop Incentive Programs for Landowner Creation of Important Habitats. The California Legislature has resolved that the state's wetland acreage should be

increased by 50 percent by the year 2000. To help achieve this goal, tax and other incentive programs should be developed to reward landowners for the creation of new permanent or temporary wetlands and to increase other important habitats. Legislation is needed to permit agreements between landowners and state and federal resource agencies for the development of significant temporary habitats without permanent dedication of the land.

8. <u>Establish Legal Protection for Rare Natural Communities</u>. The rarest and most threatened natural communities in California should be given legal protections similar to those now given legally designated rare, threatened, and endangered species and wetland plant communities. These protections could reduce losses in the amount or quality of imperiled communities, thereby minimizing the eventual need to list dependent species as threatened or endangered.

   Formal designation of a rare or endangered community would require careful documentation of the community's biological status. Criteria used to define listed communities must be determined carefully to assure that communities could be objectively and unambiguously identified on a site-specific basis. Designation and acquisition of rare habitats well in advance of encroaching land uses would reduce acquisition costs and avoid later "brinkmanship" conflicts.

9. <u>Increase Control of Nonnative Plants and Animals</u>. Many highly invasive exotic plants (e.g., French broom, tamarisk, and pampas grass) frequently escape from cultivation, displace native plants, and degrade wildlife habitat (McClintoch 1987). CNPS has sponsored a bill to prohibit or control the sale and horticultural use of such plants, but it has not been passed into law.

   Increased efforts are also needed to control nonnative animals, such as the feral pig, feral burro, brown-headed cowbird, and starling, that are disrupting native animal populations and habitats. Such efforts may require both legislative and administrative actions. The feral pig poses a particularly important threat to many parklands and other reserves (DeBenedetti 1987, Willy 1987). Improvement in control efforts may include increased direct control by agencies through trapping and shooting, streamlining procedures for private controls, regulating transport, and requiring hunting fees and a hunter reporting system to provide information and generate money for control efforts.

10. Review Effectiveness of Existing Laws and Regulations to Protect Diversity. A thorough review of existing laws and regulations is warranted to determine: 1) the extent to which current laws protect threatened and endangered species and rare natural communities, 2) the effectiveness of agency regulations in interpreting, implementing, and enforcing these laws, and 3) compliance by agencies and private individuals with laws and regulations. This review may lead to proposals for new legal protections or specific agency reforms to assure that the legislative intent to protect biological resources is achieved.

11. Evaluate Laws and Programs Detrimental to Biological Resources. A detailed review of existing laws and programs that adversely impact biological resources should be conducted. Despite current legal protections, state and federal laws governing taxation, land-use regulation, agriculture practices, forest management, energy and minerals exploration and development, and water use and development have contributed to a decline in species and habitats. Specific detrimental regulatory provisions should be identified and potential amendments should be evaluated and adopted, as appropriate.

12. Evaluate Compliance and Effectiveness of Mitigation Measures Adopted Under CEQA and NEPA. Both CEQA and NEPA acts require that mitigation measures be identified and accomplished to avoid or offset significant environmental effects unless a statement of overriding concern is prepared. Mitigation measures may include avoiding, minimizing, or compensating for impact to biological resources. Mitigation measures are routinely adopted in EISs and EIRs prepared for projects in California. Typically, a responsible party is identified to ensure that work is accomplished. Often, however, formalized procedure is required to certify that required measures have been accomplished or that the measures achieved the intended ultimate result.

    A systematic study is needed to evaluate the extent to which adopted mitigation measures are being implemented and to determine their effectiveness in preventing or minimizing impacts to biological resources. The study should evaluate a range of project types and sizes. It should identify legislative actions or administrative procedures needed to achieve the protections originally intended in environmental laws.

13. Prepare Periodic Reviews of the Status of National Diversity in California. The California Endangered Species Act requires that DFG prepare an annual status report for all state-listed threatened, endangered,

and candidate species and that each threatened and endangered species be reviewed in detail every 5 years. The law should be amended to incorporate designated rare plants into these reports. A comprehensive evaluation of the status of natural diversity in California should also be prepared periodically (at least once every 5 years) for the governor and legislature to summarize results of ongoing reviews of candidate and listed species, species of special concern, and rare habitats.

14. Include a Report on Natural Heritage in the Governor's State of the State Report. The Governor should include a report on the status of California's natural heritage in his annual state of the state report. This would provide an important opportunity to educate the general public concerning state achievements and demonstrate the state's firm dedication to protecting California's species and habitats for all Californians.

Although substantial efforts have been made to protect biological resources in California, much of California's extraordinary natural diversity remains threatened. Californians must work more vigorously to prevent the continuing loss of biological diversity. Cooperative efforts by lawmakers, agencies, scientists, planners, landowners, developers, business people, educators, and concerned citizens are essential to this effort. Success will require the hard work, creativity, and commitment of all involved. Future generations of Californians will measure their esteem for us largely by the degree to which we succeed in this important task.

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Chapter 7

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Chapter 8

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Appendix 1

SCIENTIFIC NAMES OF PLANT AND WILDLIFE
SPECIES MENTIONED IN THE REPORT

PLANTS

TREES AND SHRUBS

Blackberry	_Rubus ursinus_
Box-elder	_Acer negundo_
Button-willow	_Cephalanthus occidentalis_
California grape	_Vitus californicus_
Catalina ironwood	_Lyonothamnus floribundus_
Congdon's silktassel	_Garrya congdonii_
Cottonwood	_Populus fremontii_
Cypresses	_Cupressus_ spp.
McNap cypress	_C. macnabiana_
Santa Cruz cypress	_C. abramsiana_
Sargent cypress	_C. sargentii_
Dedeckera	_Dedeckera eurekensis_
Elderberry	_Sambucus glauca, S. mexicana_
French broom	_Cytisus monspessulanus_
Giant sequoia	_Sequoiadendron giganteum_
Manzanitas	_Arctostaphylos_ spp.
Laurel Hill manzanita	_A. hookeri_ subsp. _franciscana_
Presidio manzanita	_A. hookeri_ subsp. _ravenii_
Oaks	_Quercus_ spp.
Blue oak	_Q. douglasii_
Coast live oak	_Q. agrifolia_
Engelmann oak	_Q. engelmannii_
Leather oak	_Q. durata_
Valley oak	_Q. lobata_
Pines	_Pinus_ spp.
Jeffrey Pine	_P. jeffreyi_
Ponderosa pine	_P. ponderosa_
Torrey pine	_P. torreyana_
Tamarisk	_Tamarix_ spp.
Wild grape	_Vitus californicus_
Willow	_Salix_ spp.

HERBACEOUS PLANTS

Antioch Dunes evening primrose	_Oenothera deltoides howellii_
Baker's meadow foam	_Limnanthes bakeri_
Bedstraw	_Galium_ spp.
Blue wildrye	_Elymus glaucus_
California caulanthus	_Caulanthus californicus_
Colusa grass	_Neostapfia colusana_

Deer grass	Muhleubergia rigens
Downingia	Downingia spp.
Dwarf flax	Hesperolinon spp.
Enterprise clarkia	Clarkia mosquinii subsp. xerophila
Jewel flower	Streptanthus spp.
Live-for-ever	Dudleya spp.
McDonald's rock-cress	Arabis macdonaldiana
Meadowfoam	Limnanthes spp.
Mesa-mints	Pogogyne spp.
Otay mesa-mint	P. nudiuscula
San Diego mesa-mint	P. abramsii
Needlegrasses	Stipa
Nodding needlegrass	S. cernua
Purple needlegrass	S. pulchra
Orcutt grasses	Orcuttia spp., Tuctoria spp.
California Orcut grass	O. californica
Pampas grass	Cortaderia jubata
Phacelia	Phacelia spp.
Pine bluegrass	Poa scabrella
Prostrate spineflower	Navarretia fossalis
San Benito evening-primrose	Camissonia benitensis
San Mateo thornmint	Acanthomintha obovata subsp. duttonii
Santa Cruz wallflower	Erysimum teretifolium
Santa Suzana tarplant	Hemizonia minthornii
Tiburon jewel flower	Streptanthus niger
Tiburon mariposa-lily	Calochortus tiburonensis

ANIMALS

INVERTEBRATES

Pasadena freshwater shrimp	Syncaris pasadenae
Sooty crayfish	Pacifasticus nigrescens
Antioch Dunes katydid	Idiostatus middlekauffi
Yorba Linda trignoscuta weevil	Trigonoscuta yorbalindae
Fort Ross trigonoscuta weevil	Trigonoscuta rossi
Antioch weevil	Diaticheus rotundicollus
Mono Lake hygrotus diving beetle	Hygrotus artus
Valley mydas fly	Raphiomydas trochilus
Antioch robber fly	Cophura hurdi
Voluntine stonemyian tabanid fly	Stonemyia volutine
Pheres blue butterfly	Icaricia icaricides pheres
Sthelene wood nymphy butterfly	Cercyonis sthenele sthenele
Bay checkerspot butterfly	Euphydryas editha bayensis
Palos Verdes blue butterfly	Glaucopsyche lygdamus palosverdesensis
Atossa frittillary butterfly	Speyeria adiaste atosse
Storhbeen's parnassian butterfly	Parnassius dodius strohbeeni
Xerxes blue butterfly	Glaucopsyche xerces
Castle Lake rhyacophilan caddisfly	Rhyacophila amabilis
Yellow-banded audrenid bee	Perdita hirticeps luteocincta
Antioch sphecid wasp	Philanthus nasalis

FISHES

Chinook salmon	*Oncorhynchus tshawytscha*
Shoshone pupfish	*Cyprinodon nevadensis shoshone*
Tecopa pupfish	*Cyprinodon nevadensis calidae*
Clear Lake splittail	*Pogonichthys ciscoides*
Thick-tail chub	*Gila crassicauda*
Bull trout	*Salvelinus confluentus*
Killifish	*Empetrichthys* spp.

AMPHIBIANS

Ensatina salamander	*Ensatina eschscholtzi*
Mount Lyell salamander	*Hydromantes platycephalus*
Limestone salamander	*Hydromantes brunus*
Blunt-nosed leopard lizard	*Gambelia silus*

REPTILES

California legless lizard	*Anniella pulchra*
Western pond turtle	*Clemmys marmorata*

BIRDS

Common loon	*Gavia immer*
Ashy storm-petrel	*Oceanodroma homochroa*
American white pelican	*Pelecanus erythrorhynchas*
Tundra swan	*Cygnus columbianus*
Snow goose	*Chen caerulescens*
Ross' goose	*Chen rossii*
Greater white-fronted goose	*Anser albifrons*
Pacific white-fronted goose	*A. a. albifrons*
Tule goose	*A. a. elagasi*
Canada goose	*Branta canadensis*
Aleutian Canada goose	*B. c. leucopareia*
Cackling Canada goose	*B. c. minima*
Green-winged teal	*Anas crecca*
Mallard	*Anas platyrhynchos*
Northern pintail	*Anas acuta*
Cinnamon teal	*Anas cyanoptera*
Northern shoveler	*Anas clypaeta*
Gadwall	*Ana strepera*
American wigeon	*Anas americana*
Canvasback	*Aythya valisineria*
Ring-necked duck	*Aythya collaris*
Harlequin duck	*Histrionicus histrionicus*
Barrow's goldeneye	*Bucephale islandica*
California condor	*Gymnogyps californianus*
Bald eagle	*Haliaeetus leucocephalus*
Harris' hawk	*Parabuteo unicinctus*
Swainson's hawk	*Buteo swainsoni*
Sharp-tailed grouse	*Tympanuchus phasianellus*
Yellow rail	*Coturnicops noveboracensis*
Sandhill crane	*Grus canadensis*

Elegant tern	_Sterna elegans_
Xantu's murrelet	_Synthliboramphus hypoleucus_
California Yellow-billed cuckoo	_Coccyzus americanus occidentalis_
Spotted owl	_Stryx occidentalis_
Willow flycatcher	_Empidonax trailii_
Bank swallow	_Riparia riparia_
Yellow-billed magpie	_Pica nuttalli_
San Clemente Bewick's wren	_Thryomanes bewickii leucophrys_
California thrasher	_Toxostoma redivivum_
European starling	_Sturnus vulgaris_
Least Bell's vireo	_Vireo bellii pusillus_
Warbling vireo	_Vireo gilvus_
Yellow warbler	_Dendroica petechia_
Lazuli bunting	_Passerina amoena_
Santa Barbara song sparrow	_Melispiza melodia graminea_
Borwn-headed cowbird	_Molothrus ater_

MAMMALS

Riparian brush rabbit	_Sylvilagus bachmani riparius_
San Joaquin kangaroo rat	_Dipodomys nitratoides_ subspp.
Tipton kangaroo rat	_Dipodomys nitratoides nitratoides_
Grant deer mouse	_Peromyscus nesodytes_
Beaver	_Castor canadensis_
Wolf	_Canis lupus_
Kit fox	_Vulpes macrotis_
San Joaquin kit fox	_V. m. mutica_
Long-eared kit fox	_V. m._ macrotis
Black bear	_Ursus americanus_
Grizzly bear	_Ursus arctos_
River otter	_Lutra canadensis_
Jaguar	_Felis onca_
Mountain lion	_Felis concolor_
Feral pig	_Sus scrofa_
Mule deer	_Odocoileus hemionus_
White-tailed deer	_Odocoileus virginianus_
Feral burro	_Equus asinus_
Tule elk	_Cervus elpahus nannodes_
Pronghorn	_Antilocapra americana_
Bighorn sheep	_Ovis canadensis_

Appendix 2

ACRONYMS LIST

ACEC	Area of Critical Environmental Concern
BLM	Bureau of Land Management
CDF	California Department of Forestry
CEQA	California Environmental Quality Act
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CNPS	California Native Plant Society
COE	U. S. Corps of Engineers
DFG	California Department of Fish and Game
DPR	California Department of Parks and Recreation
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
EPA	U. S. Environmental Protection Agency
ESA	Endangered Species Act
FLPMA	Federal Land Policy Management Act
JSA	Jones & Stokes Associates
LNAP	Lands and Natural Areas Program
NDDB	Natural Diversity Data Base
NEPA	National Environmental Policy Act
NPS	National Park Service
NWR	National Wildlife Refuge
RNA	Research Natural Area
SVWHMC	Sacramento Valley Waterfowl Habitat Management Committee
THP	Timber Harvest Plan
TNC	The Nature Conservancy
USFS	U. S. Forest Service
USFWS	U. S. Fish and Wildlife Service
WCB	Wildlife Conservation Board

C-056932

Appendix 3

SUMMARY OF MAJOR FEDERAL AND STATE LAWS THAT HELP TO PROTECT NATURAL DIVERSITY

Federal Laws

Migratory Bird Treaty Act

This act prohibits the capture, killing, or possession of any bird species identified by various international conventions. Conventions to protect migratory birds have been signed with Great Britain, Mexico, Japan, and Russia. This act provides the federal government with authority to establish threshold regulations that govern the hunting and management of listed species. The Act does not provide for acquisition of habitat.

National Wildlife Refuge System Administration Act

This act consolidated wildlife refuge administrative units under the jurisdiction of the USFWS, or the joint jurisdiction of USFWS and BLM. The act has simplified the administration of land acquisition and disposition. Management of habitat remains varied and decentralized. Regulations pursuant to the act permit use of refuges for any purpose deemed compatible with the major purpose of the refuge. Many of the National Wildlife Refuges in California are managed intensively for waterfowl and other wetland-dependent birds. Although habitats are not strictly natural, they support populations of many species that contribute importantly to the state's wildlife diversity.

Water Bank Act

This act authorizes the Secretary of Agriculture to enter into agreements with landowners in migratory waterfowl habitat areas to protect the wetland character of their lands. This program protects some wetlands for waterfowl use but does not exclusively maintain natural habitats.

Endangered Species Act (ESA)

This act prohibits all federal activity from adversely affecting any federally threatened or endangered species or their designated critical habitats. The act also establishes a process for consultation and evaluation by USFWS of proposed federal projects by USFWS. Through the consultation process and specific provisions for habitat preservation, the ESA provides strong federal protection for species and habitat diversity, especially in cases where habitat loss has caused species endangerment. Federal courts have consistently interpreted the Act to afford strong protection to protected species and their habitat.

National Environmental Policy Act

This act requires all federal agencies to assess the impacts of proposed actions on the environment, examine alternatives, and propose mitigation measures for significant adverse impacts. These measures ensure that environmental factors are considered by decision makers and provide for public involvement in environmental decision making. An Environmental Impact Statement (EIS) is commonly prepared to comply with NEPA's requirements. NEPA does not specifically require measures to preserve habitat diversity. The identification of impacts and alternatives to proposed actions often results, however, in decisions to avoid, minimize, or compensate for losses of particularly valuable or scarce habitats.

Multiple Use - Sustained Yield Act

This act recognizes the USFS authority to manage National Forests for purposes other than timber harvest and watershed protection. Other uses, including wildlife and fisheries resources, are to be given "due consideration." The act does not specify the extent of consideration when preservation of wildlife habitat conflicts with other land and resource uses.

National Forest Management Act

This act establishes the USFS' planning goals and processes for development of management plans on each National Forest. The act and its subsequent regulations address a number of diversity issues. The act requires that forests be managed to "provide for diversity of plant and animal communities" and specifies other objectives that protect diversity, including protection of streams, lakes, and other wetlands, and protection of soil, watershed, fish, and wildlife. Steps must be taken to maintain or increase diversity of plant and animal species and communities by management and to maintain viable populations of all native vertebrate wildlife populations. However, these guidelines are complemented by strong language supporting timber harvest and other intensive resource management activities.

Federal Land Policy Management Act (FLPMA)

This act requires study of certain BLM lands for inclusion into the National Wilderness Preservation System and preparation of integrated management plans. Although most of the land use plans must follow the Multiple Use - Sustained Yield Act or similar dictates, FLPMA created management provisions that contribute to protection of important habitats, including ACEC land use category. This category is intended to prevent damage to important fish and wildlife resources and other natural systems or processes. Compatible land uses are permitted in ACECs.

Wilderness Act

This act directs that lands within the National Wilderness Preservation System be managed to preserve their wilderness character. Permanent roads and other activities that disturb habitat and wilderness character are prohibited. The act provides substantial habitat protection, although grazing practiced before wilderness designation is usually allowed to continue.

Wild and Scenic Rivers Act

This act is intended to protect the freeflowing, natural conditions of rivers designated by Congress. Such designation protects a river and a 0.25-mile corridor from development. Currently, portions of the Tuolumne, American, Middle Fork Feather, Smith, Klamath, Trinity, and Eel Rivers are classified under this federal program in California.

Clean Water Act

Section 404 in the Clean Water Act regulates discharge of materials into "waters of the U. S." Under this provision, COE must issue permits for deposit of fill in waterways and wetland areas on both public and private lands. Other federal agencies (e.g., USFWS and the Environmental Protection Agency [EPA]) provide recommendations concerning whether permits should be issued and under what conditions. Since its enactment, this program has been extremely valuable in protecting wetland areas from filling for other uses.

State Laws

California Endangered Species Act

This act establishes a state policy to conserve, protect, restore, and enhance designated threatened and endangered species and their habitats. The act authorizes the acquisition of habitat to conserve threatened and endangered species. The act also protects listed fish, wildlife, and plant species from unauthorized taking, importation, exportation, or sale. An exemption, however, greatly reduces the protection from taking of plants on private land.

The act establishes a consultation process between state agencies and DFG. If DFG determines that a project will jeopardize a designated species or adversely modify its essential habitat, the lead agency must implement DFG's alternatives to avoid jeopardy. The act, however, includes exceptions to the alternatives requirement and applies only to state-approved projects; private projects do not require consultation under the act.

California Environmental Quality Act

This act requires state and local agencies to evaluate the environmental impacts of proposed projects. Where impacts are significant, agencies must adopt mitigation measures to minimize impacts. Impacts to habitat diversity may be determined to be significant. The environmental impact requirement of CEQA also requires public involvement in the decision-making process.

CEQA provides assistance in avoiding or mitigating impacts to habitat types. However, it provides no centralized or systematic approach for dealing with problems of maintaining habitat diversity. CEQA also provides that agencies can approve or undertake projects which will significantly impact the environment if the agency makes specific findings of overriding social or economic considerations.

Wildlife Conservation Law

This law establishes a three-member WCB to select and acquire lands and facilities for recreational use and for conservation, propagation, and utilization of the state's fish and game. WCB has purchased many important habitat areas that contribute to diversity protection; most of these properties are managed by DFG. The Wildlife Conservation Law allows the use of eminent domain except for acquisition of agricultural land. Potential conflicts with habitat preservation may occur in some areas that are managed for intensive public access and recreation.

California Wetlands Preservation Act

This act establishes a state policy of preserving, restoring, and enhancing wetlands; authorizes DPR as well as DFG to acquire wetlands; and encourages state agencies to cooperate with local agencies in wetlands management. The act does not specify how the wetlands are to be managed or specify what land uses are allowed. Implementing regulations for the law are currently being prepared.

Native Species Conservation and Enhancement Act

This act establishes a state policy of maintaining habitat necessary to ensure the continued existence of all native species of wildlife and plants. The Act, which establishes funding mechanisms for acquisition and management of lands has been used to preserve a considerable amount of habitat in California. The Fish and Game Commission is responsible for implementing this act.

California Wild and Scenic Rivers Act

This act identifies a state program to protect the freeflowing condition of designated rivers. Rivers are designated to protect outstanding scenic, recreational, fishery, and wildlife values. The act prohibits construction of dams, reservoirs, or diversions. Unlike the federal Wild and Scenic Rivers Act, this Act offers no specific land use protections to habitat corridors adjoining the protected rivers. To date, protection has been given to the Smith, Klamath, Trinity, Eel, and American Rivers. The McCloud, East Carson, and West Walker Rivers are currently under study (Dunn pers. comm.)

Native Plant Protection Act

This act prohibits the taking, import, or sale of rare or endangered plant species subject to several broad exceptions. The exceptions include the possession or sale of real property on which the plant is growing, loss to agricultural practices, including the clearing of land, and loss during authorized timber harvest operations. The exceptions are limited; if DFG has notified the landowner of the presence of a rare or endangered species, the landowner must give DFG 10 days' notice before destroying protected plants to allow an attempt to salvage the species. The only lands on which the act affords full protection are public lands with uses other than resource development.

California Wilderness Act

The act is similar to the federal Wilderness Act, except that it applies only to state-owned or leased lands. The predominant management goal is preservation of an area's wilderness character. Grazing and mineral development are permitted uses, however. The California Wilderness Act requires each unit to be at least 5,000 acres in size or of sufficient size as to make preservation practicable. State wildernesses are generally established within units of the state park system.

Williamson Act

This act allows landowners to enter restrictive use contracts with local governments in exchange for reduced tax assessments. Generally, the act is used to protect agricultural and grazing land from urban conversion. Many local governments also enter contracts with specific landowners to preserve open space. The contracts are limited to 10-year periods and may be revoked by governments under certain conditions.

Appendix 4

CALIFORNIA'S RARE AND IMPERILED NATURAL COMMUNITIES

TERRESTRIAL COMMUNITIES

DUNE COMMUNITIES
- Northern Coastal Foredune Grassland
- Southern Coastal Foredunes
- Northern Coastal Dune Scrub
- Central Coastal Dune Scrub
- Southern Coastal Dune Scrub
- Active Desert Dunes
- Stabilized and Partially Stabilized Desert Dunes
- Stabilized and Partially Stabilized Desert Sand Fields
- Stabilized Interior Dunes
- Relictual Interior Dunes (Antioch)
- Monvero Residual Dunes

SCRUB AND CHAPARRAL COMMUNITIES
- Northern Coastal Bluff Scrub
- Southern Coastal Bluff Scrub
- Maritime Succulent Scrub
- Diegan Coastal Sage Scrub
- Riversidian Sage Scrub
- Valley Sink Scrub
- Valley Saltbush Scrub
- Interior Coast Range Saltbush Scrub
- Gabbroic Northern Mixed Chaparral
- Granitic Southern Mixed Chaparral
- Mafic Southern Mixed Chaparral
- Mixed Serpentine Chaparral
- Leather Oak Chaparral
- Island Chaparral
- Northern Maritime Chaparral
- Central Maritime Chaparral
- Southern Maritime Chaparral
- Ione Chaparral

GRASSLAND, VERNAL POOL, MEADOW, AND OTHER HERB COMMUNITIES
- Coastal Terrace Prairie
- Bald Hills Prairie
- Valley Needlegrass Grassland
- Valley Sacaton Grassland
- Serpentine Bunchgrass
- Pine Bluegrass Grassland
- Wildflower Field
- Great Basin Grassland

Northern Hardpan Vernal Pool
Northern Claypan Vernal Pool
Northern Basalt Flow Vernal Pool
Northern Volcanic Mud Flow Vernal Pool
Southern Interior Basalt Flow Vernal Pool
San Diego Mesa Hardpan Vernal Pool
San Diego Mesa Claypan Vernal Pool
Wet Subalpine or Alpine Meadow
Dry Subalpine or Alpine Meadow
Alkali Meadow
Alkali Seep
Freshwater Seep
Alkali Playa Community
Pavement Plain Community

MARSH COMMUNITIES

Sphagnum Bog
Darlingtonia Bog
Fen
Northern Coastal Salt Marsh
Southern Coastal Salt Marsh
Coastal Brackish Marsh
Cismontaine Alkali Marsh
Transmontane Alkali Marsh
Coastal and Valley Freshwater Marsh
Transmontane Freshwater Marsh
Montane Freshwater Marsh
Vernal Marsh
Freshwater Swamp
Ledum Swamp

RIPARIAN AND BOTTOMLAND COMMUNITIES

North Coast Black Cottonwood Riparian Forest
North Coast Alluvial Redwood Forest
Red Alder Riparian Forest
Central Coast Cottonwood-Sycamore Riparian Forest
Central Coast Live Oak Riparian Forest
Central Coast Arroyo Willow Riparian Forest
Southern Coast Live Oak Riparian Forest
Southern Arroyo Willow Riparian Forest
Southern Cottonwood-Willow Riparian Forest
Great Valley Cottonwood Riparian Forest
Great Valley Mixed Riparian Forest
Great Valley Valley Oak Riparian Forest
White Alder Riparian Forest
Aspen Riparian Forest
Montane Black Cottonwood Riparian Forest
Modoc-Great Basin Cottonwood-Willow Riparian Forest
Sonoran Cottonwood-Willow Riparian Forest
Mesquite Bosque
Sycamore Alluvial Woodland
Desert Dry Wash Woodland
Desert Fan Palm Oasis Woodland
Southern Sycamore-Alder Riparian Woodland

North Coast Riparian Scrub
Central Coast Riparian Scrub
Southern Willow Scrub
Great Valley Willow Scrub
Great Valley Mesquite Scrub
Buttonbush Scrub
Elderberry Savanna
Montane Riparian Scrub
Modoc-Great Basin Riparian Scrub

WOODLAND COMMUNITIES
Open Engelmann Oak Woodland
Dense Engelmann Oak Woodland
Island Oak Woodland
California Walnut Woodland
Hinds Walnut Woodland
Elephant Tree Woodland
Crucifixion Thorn Woodland
All-thorn Woodland
Arizonan Woodland

FOREST COMMUNITIES
California Bay Forest
Walnut Forest
Island Ironwood Forest
Island Cherry Forest
Mainland Cherry Forest
Coastal Douglas-Fir-Western Hemlock Forest
Upland Douglas-Fir Forest
Port-Orford-Cedar Forest
Beach Pine Forest
Northern Bishop Pine Forest
Southern Bishop Pine Forest
Monterey Pine Forest
Torrey Pine Forest
Monterey Cypress Forest
Mendocino Pygmy Cypress Forest
Monterey Pygmy Cypress Forest
Knobcone Pine Forest
Northern Interior Cypress Forest
Southern Interior Cypress Forest
Santa Lucia Fir Forest
Maritime Coast Range Ponderosa Pine Forest
Southern Ultramafic Jeffrey Pine Forest
Eastside Ponderosa Pine Forest
Big Tree Forest
Washoe Pine-Fir Forest
Desert Mountain White Fir Forest
Siskiyou Enriched Coniferous Forest
Salmon-Scott Enriched Coniferous Forest
Foxtail Pine Forest
Bristlecone Pine Forest

AQUATIC COMMUNITIES

SACRAMENTO/SAN JOAQUIN DRAINAGE COMMUNITIES
- Valley Northeast Volcanic Perennial Pool
- Valley Dystrophic Lake
- Valley Mountain Ephemeral Pool
- Valley Rainbow Trout Stream
- Valley Golden Trout Stream
- McCloud Redband Trout Stream
- Goose Lake Redband Trout Stream
- Valley Fall/Winter Run Chinook Salmon Stream
- Valley Spring/Summer Run Chinook Salmon Stream
- Valley Steelhead Trout Stream
- Valley Glacial Milk Stream
- Valley Exposed Alpine Stream
- Valley Rheocrene (Channel Spring)
- Valley Limnocrene (Pool Spring)
- Valley Helocrene (Marsh Spring)

NORTH/CENTRAL COASTAL DRAINAGE COMMUNITIES
- North/Central Dune Lake
- Coastal Rainbow Trout Stream
- Coastal Cutthroat Trout Stream
- Coastal Chinook Salmon Stream
- Coastal Fall/Winter Run Steelhead Trout Stream
- Coastal Spring/Summer Run Steelhead Trout Stream
- Coastal Coho Salmon Stream
- Coastal Searun Cutthroat Trout Stream
- Coastal Deciduous Woodland Stream

KLAMATH DRAINAGE COMMUNITIES
- Klamath Minnow Lake
- Klamath Dune Lake
- Klamath Rainbow Trout Stream
- Klamath Redband Trout Stream
- Klamath Cutthroat Trout Stream
- Klamath Spring/Summer Run Chinook Salmon Stream
- Klamath Spring/Summer Run Steelhead Trout Stream
- Klamath Coho Salmon Stream
- Klamath Searun Cutthroat Trout Stream
- Klamath Anadromous Fishes Stream
- Klamath Chub Stream

LAHONTAN DRAINAGE COMMUNITIES
- Lahontan Perennial Playa Lake
- Lahontan Great Basin Scrub Perennial Pool
- Lahontan Cutthroat Trout Stream
- Lahontan Salmonid Spawning Tributary
- Lahontan Glacial Milk Stream

AMARGOSA DRAINAGE COMMUNITIES
- Amargosa Desert Perennial Pool

SOUTH COASTAL DRAINAGE COMMUNITIES
- South Coastal Dune Lake
- South Coastal Perennial Playa Lake
- South Coastal 'Sag Pond' Lake
- South Coastal Steelhead Trout Stream
- South Coastal Minnow/Sucker Stream

SALTON SEA DRAINAGE COMMUNITIES
- Salton Sea Desert Perennial Pool

OWENS/MOHAVE DRAINAGE COMMUNITIES
- Owens/Mojave Perennial Playa Lake
- Owens/Mojave Desert Perennial Pool

MARINE INFLUENCED AQUATIC COMMUNITIES
- North Mixosaline Estuary
- North Oligosaline Estuary
- North Mesosaline Estuary
- South Mesosaline Estuary
- North Mixosaline Lagoon
- North Eusaline Lagoon
- South Eusaline Lagoon

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